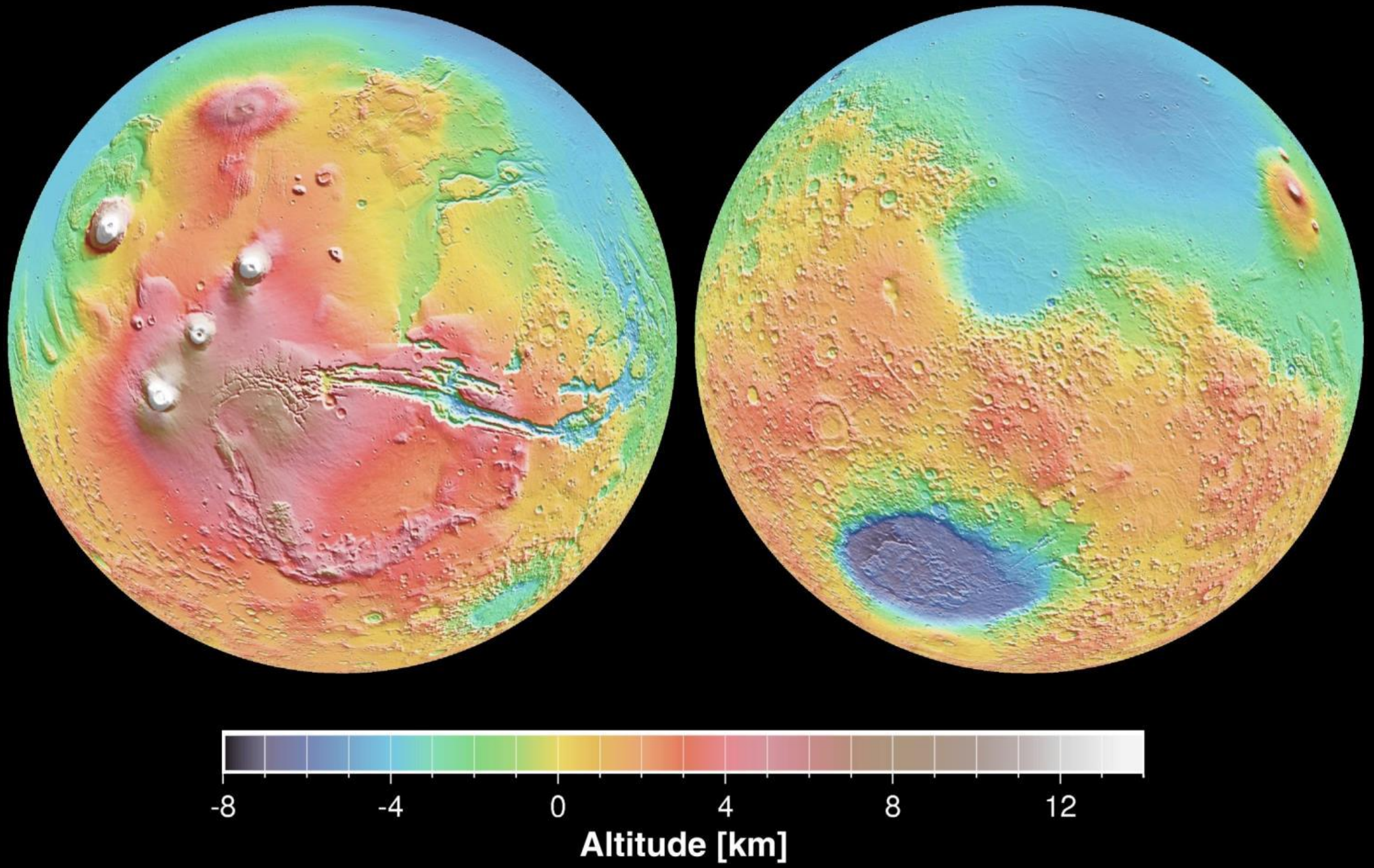
Utrecht University

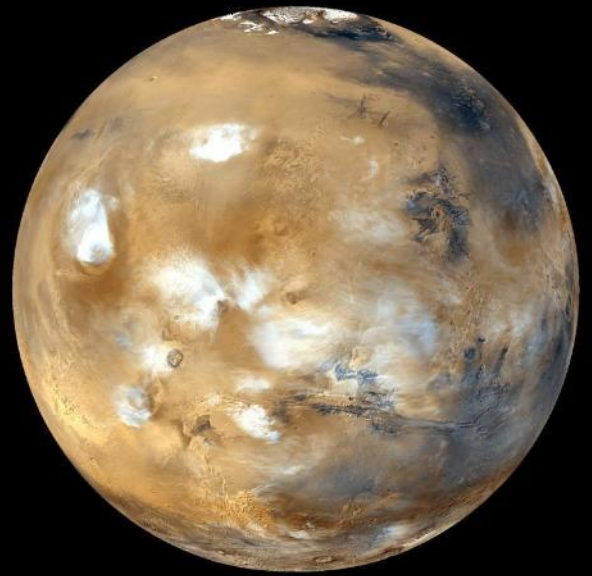
DEPARTMENT OF PHYSICAL GEOGRAPHY

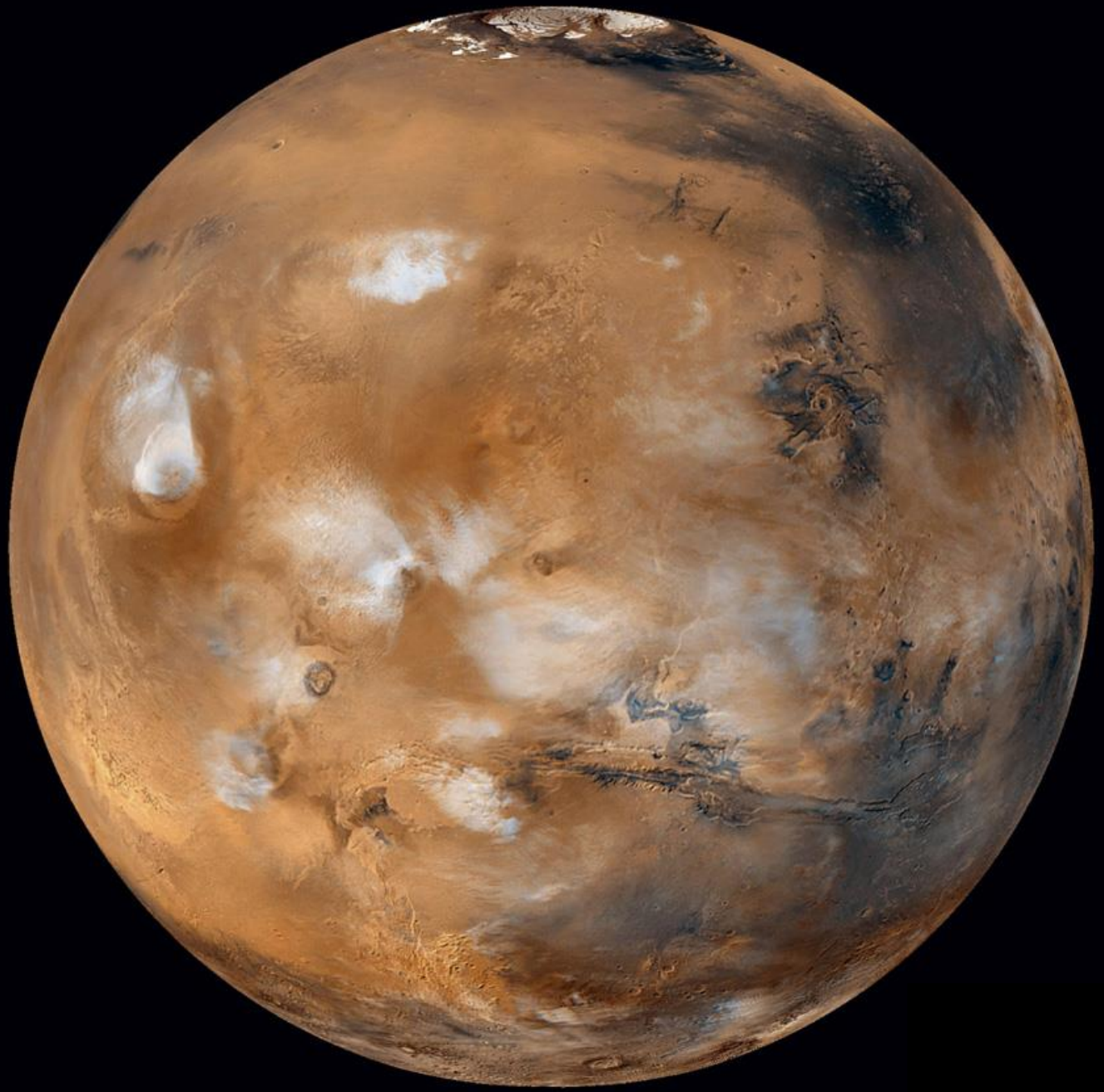
Water on Mars?

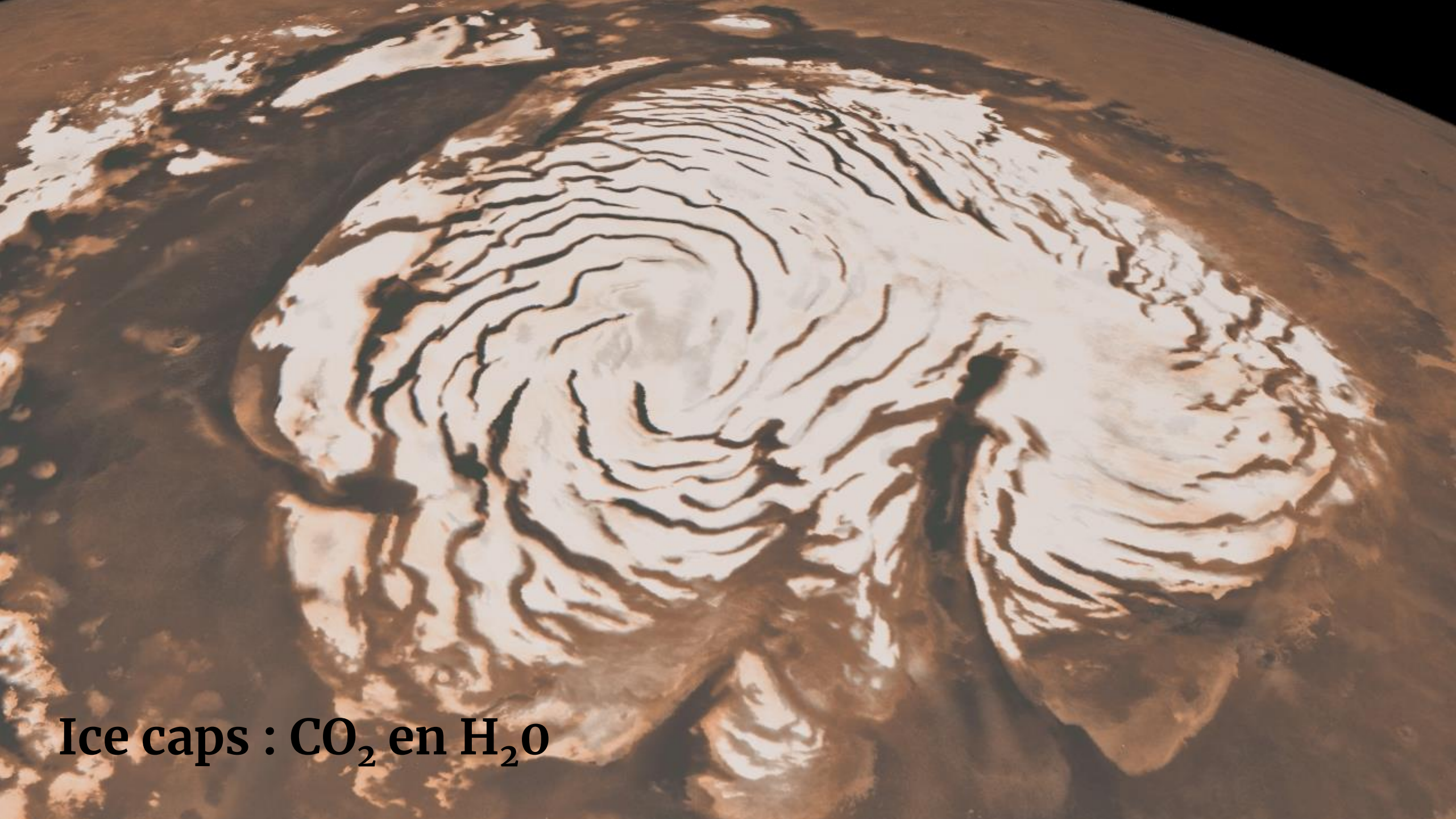
Bunnik crater, Mars

Tjalling de Haas (t.dehaas@uu.nl)

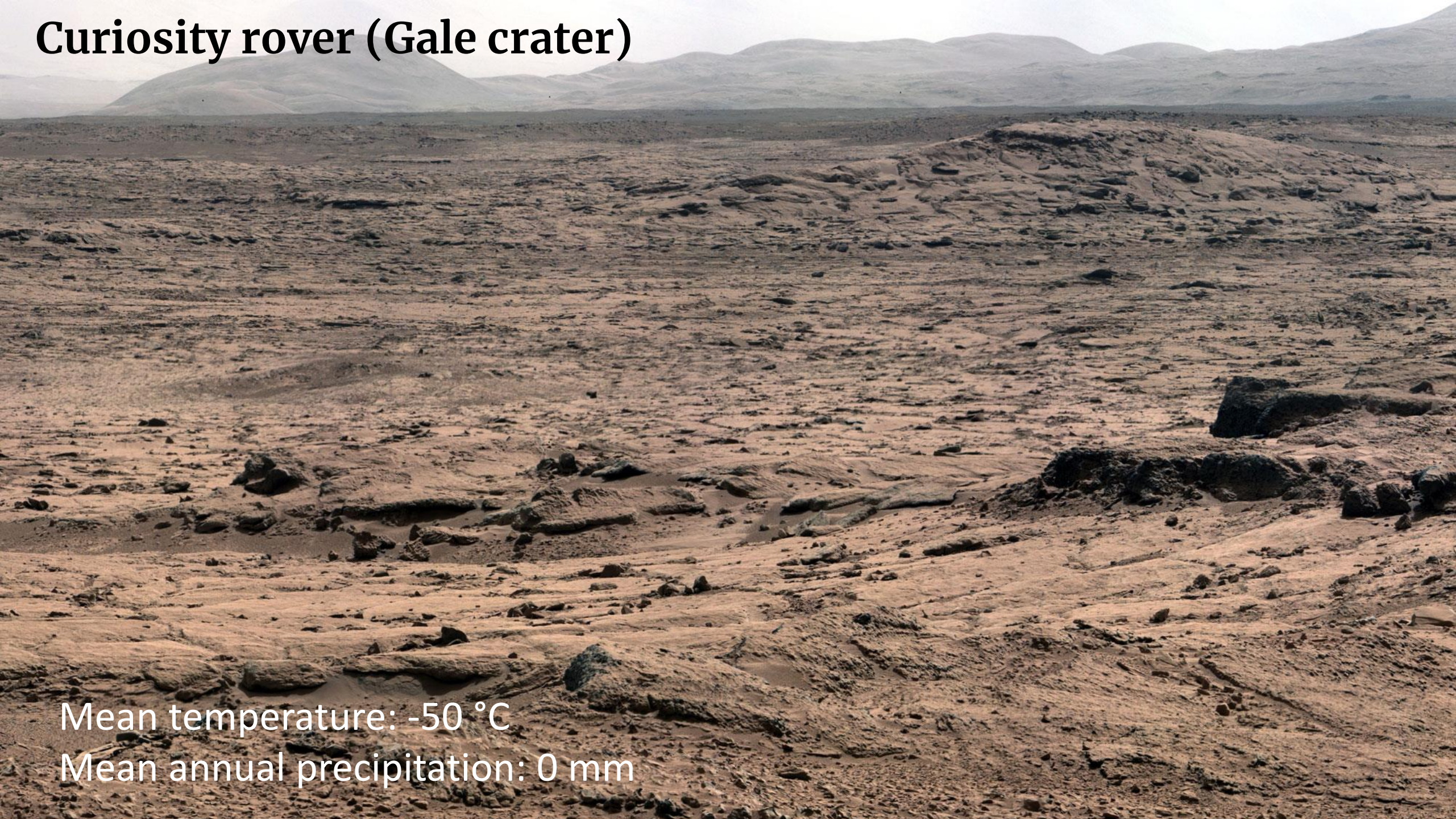

-8
-4
0
4
8
12
Altitude [km]



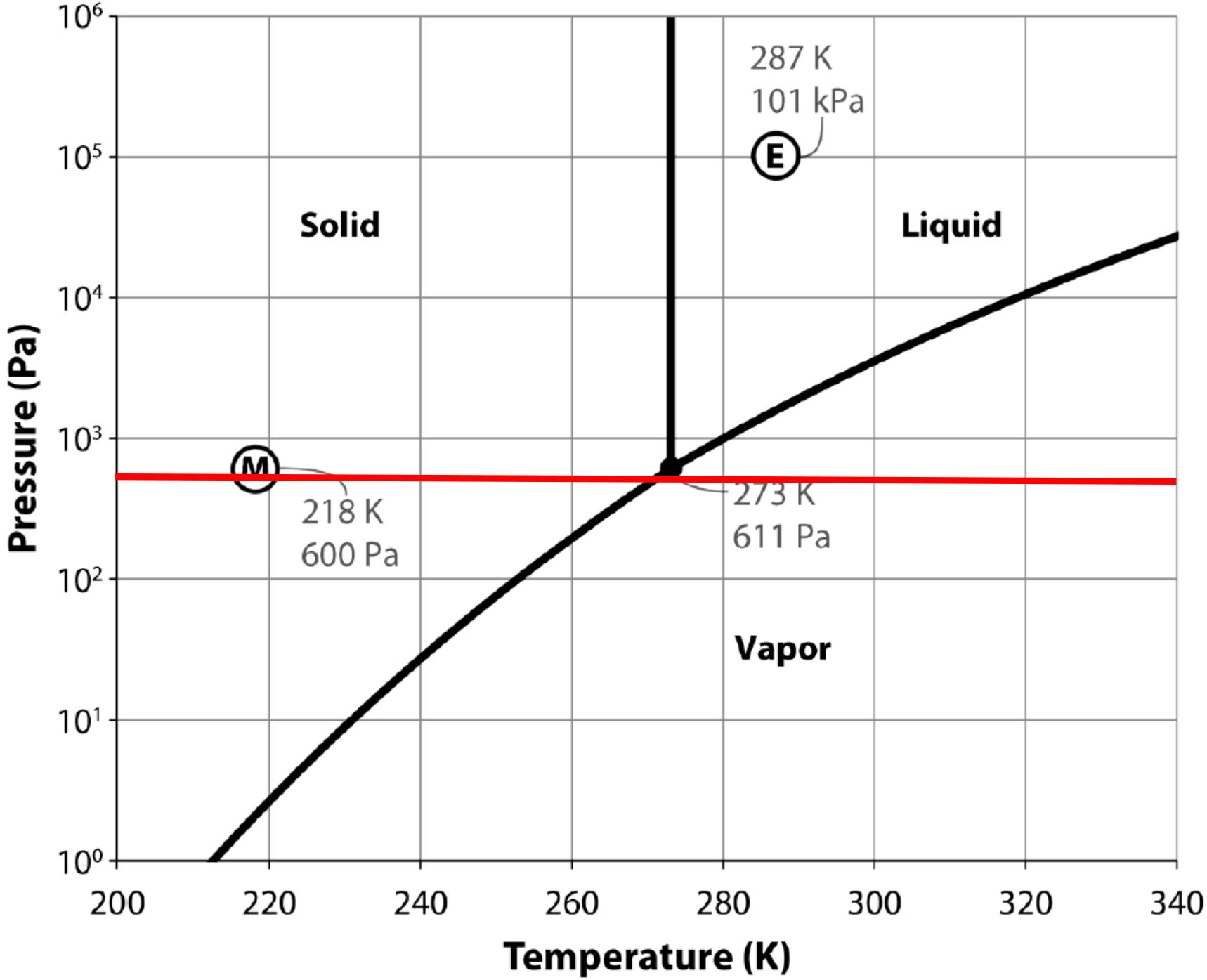



Ice caps : CO_2 en H_2O

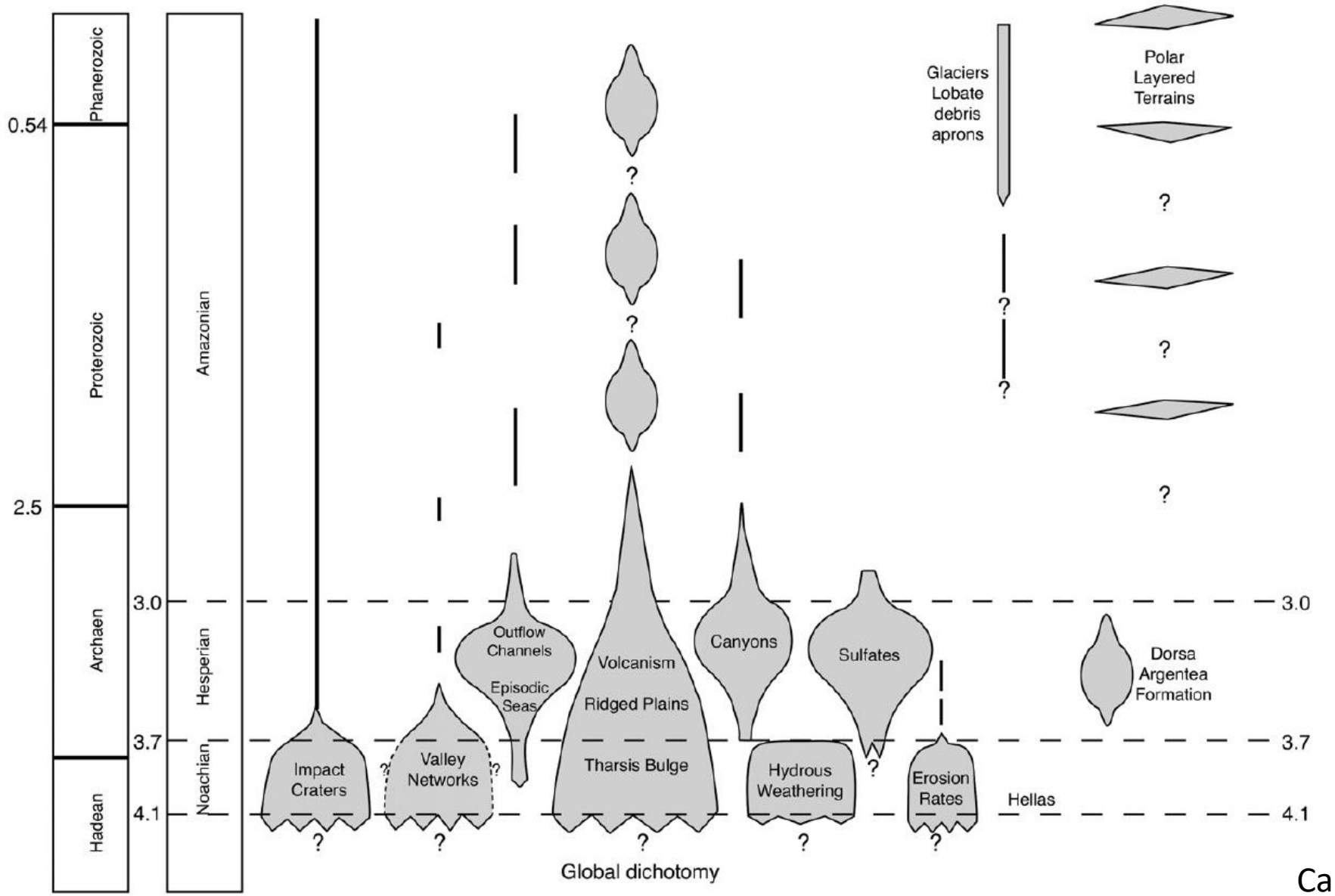
Curiosity rover (Gale crater)



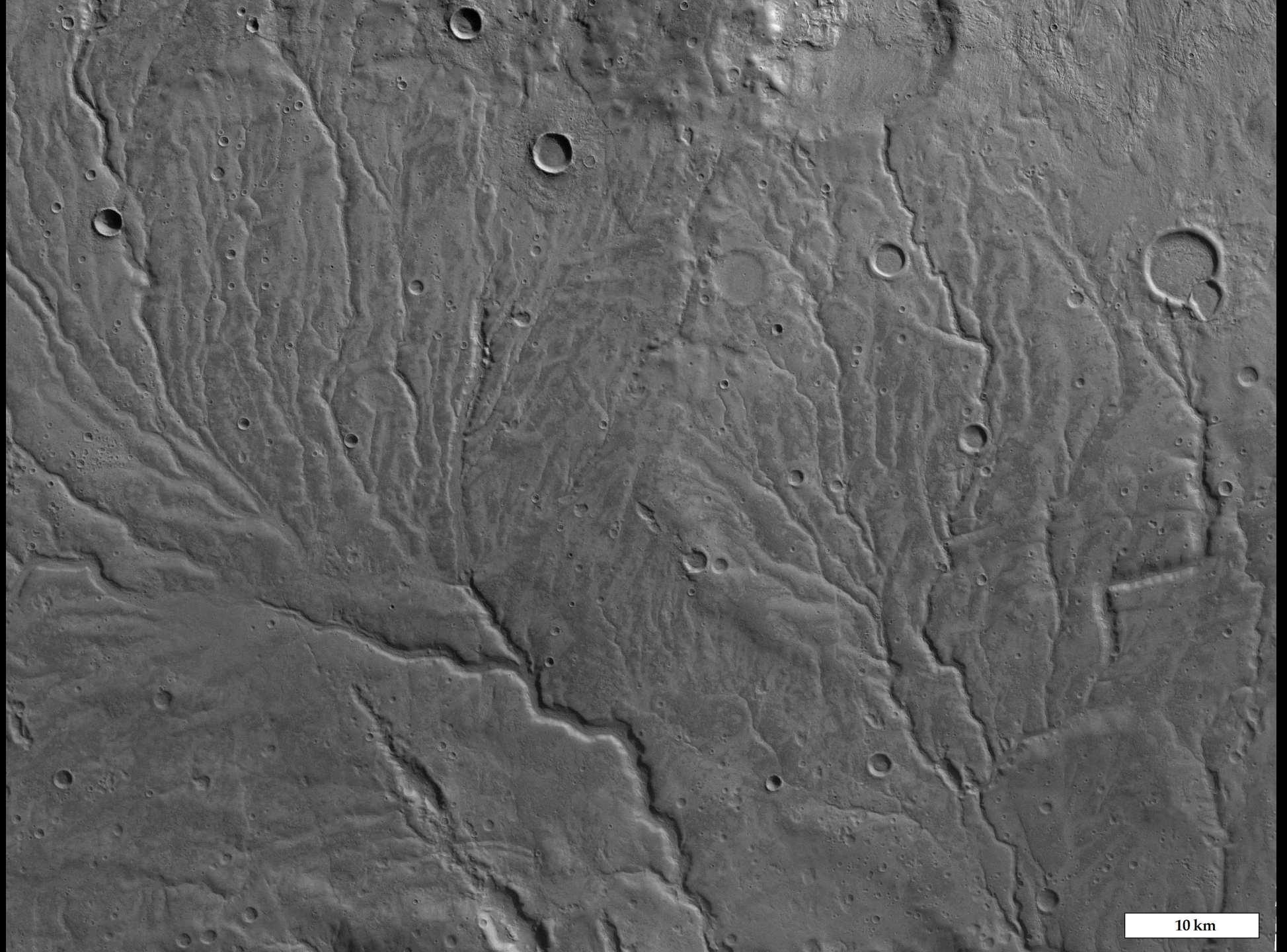
Mean temperature: -50 °C
Mean annual precipitation: 0 mm

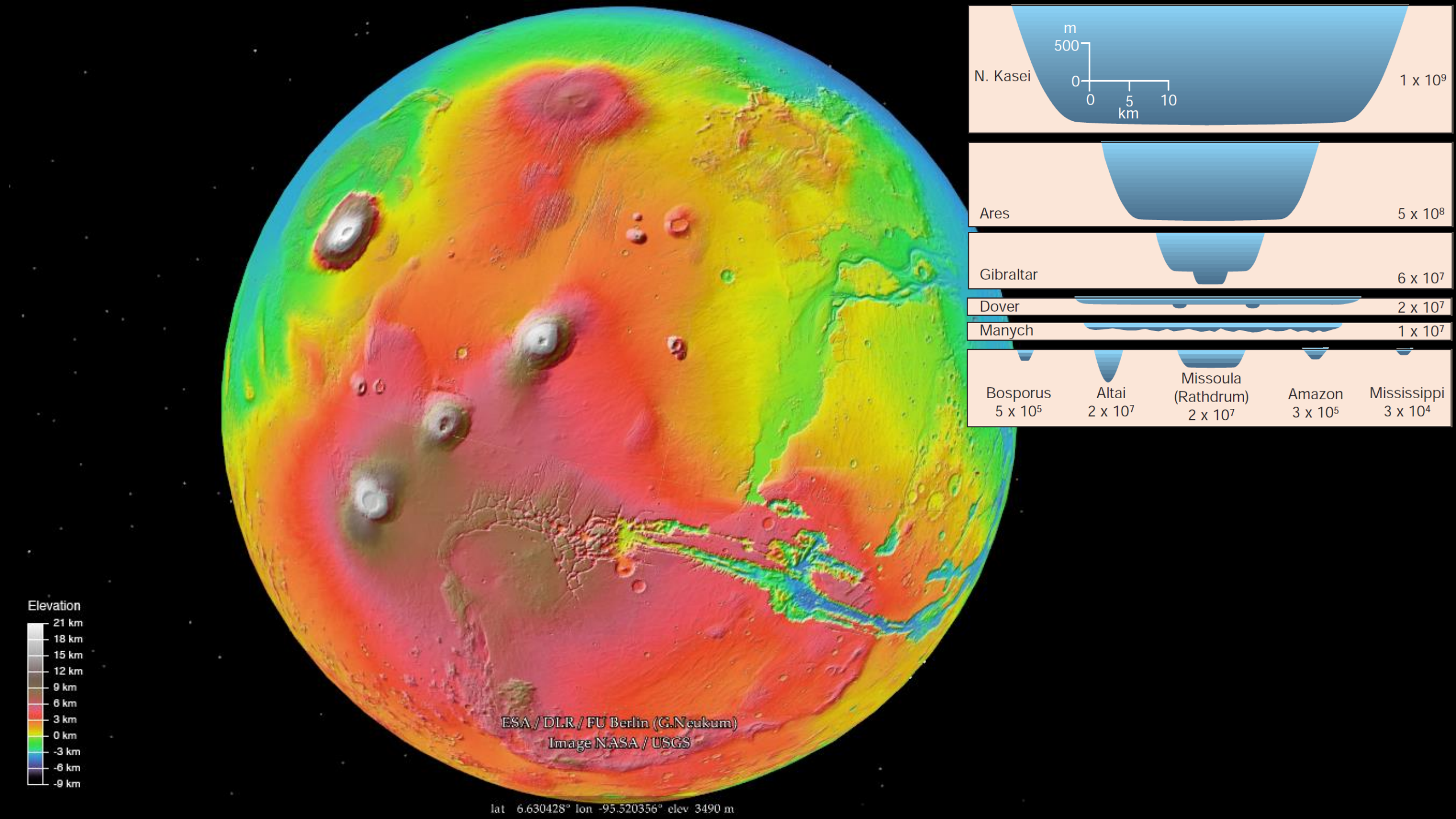

Pressure (Pa)
10^6
10^5
10^4
10^3
10^2
10^1
10^0
200
220
240
260
280
300
320
340
Temperature (K)
Solid
Liquid
Vapor
287 K
101 kPa
E
M
218 K
600 Pa
273 K
611 Pa

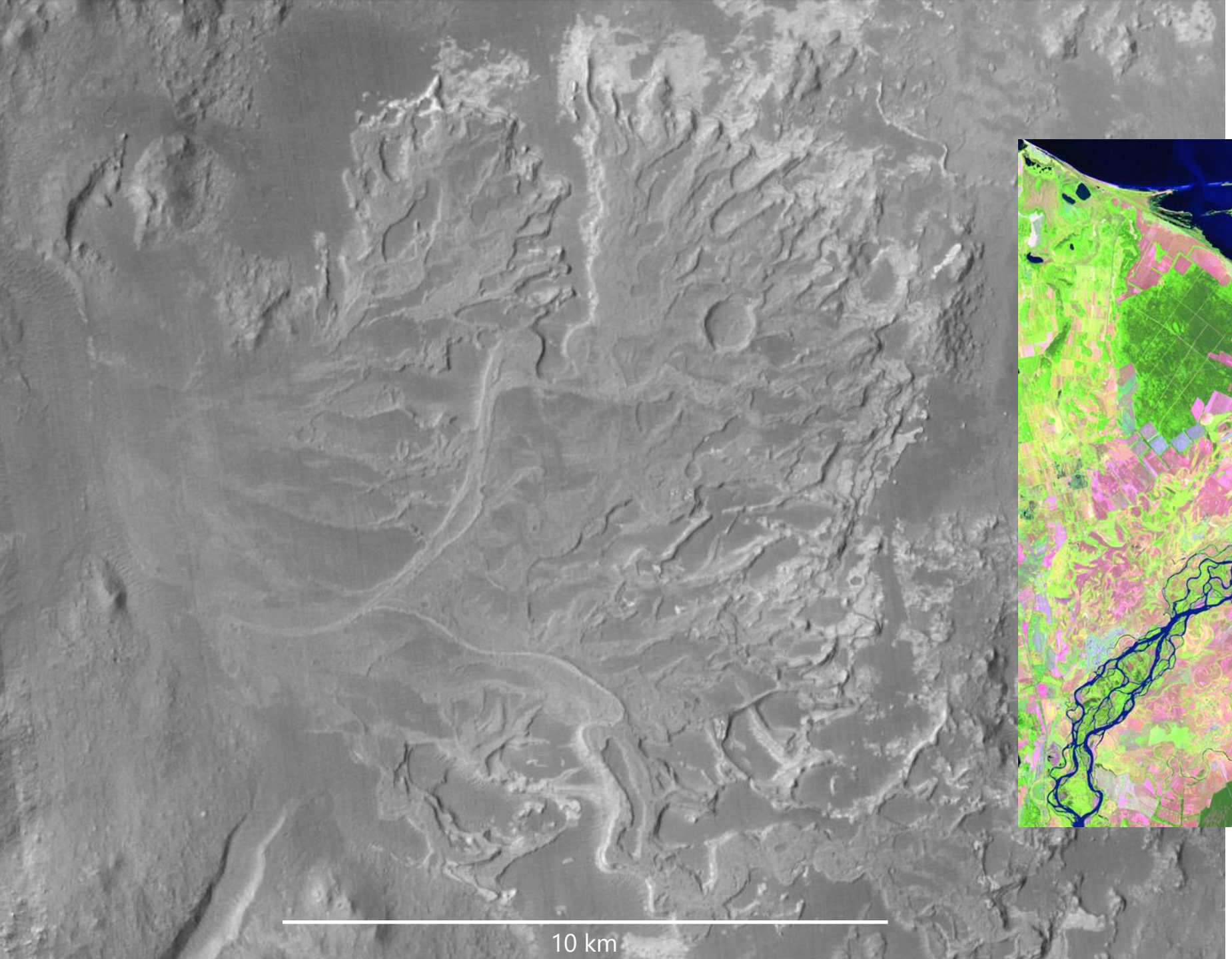
Geological history of Mars

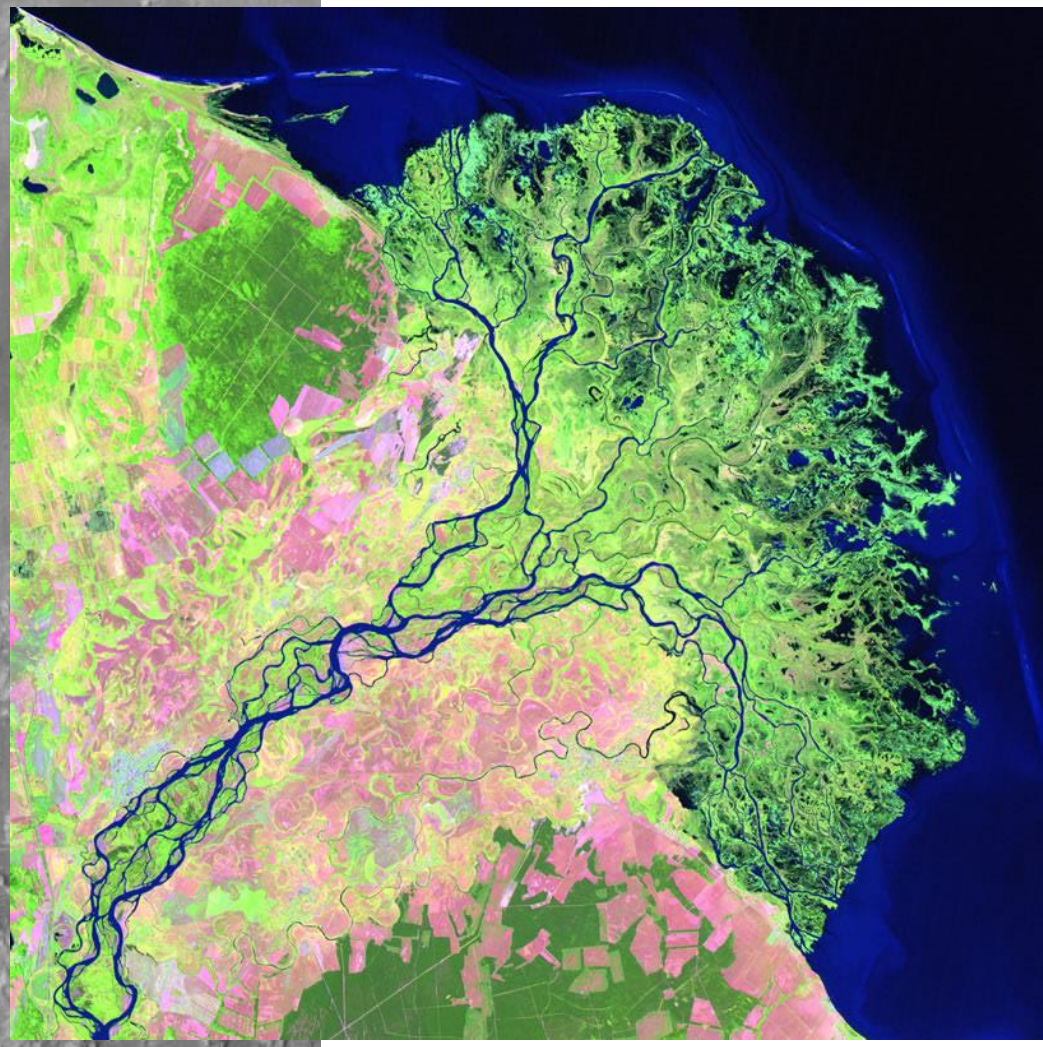


Carr and Head, 2010


10 km


Elevation
21 km
18 km
15 km
12 km
9 km
6 km
3 km
0 km
-3 km
-6 km
-9 km
ESA / DLR / FU Berlin (G.Neukum)
Image NASA / USGS
lat 6.630428° lon -95.520356° elev 3490 m
m
500
0
0
5
10
km
N. Kasei
1 x 10⁹
Ares
5 x 10⁸
Gibraltar
6 x 10⁷
Dover
2 x 10⁷
Manych
1 x 10⁷
Bosporus
5 x 10⁵
Altai
2 x 10⁷
Missoula
(Rathdrum)
2 x 10⁷
Amazon
3 x 10⁵
Mississippi
3 x 10⁴


10 km



Stromend water!

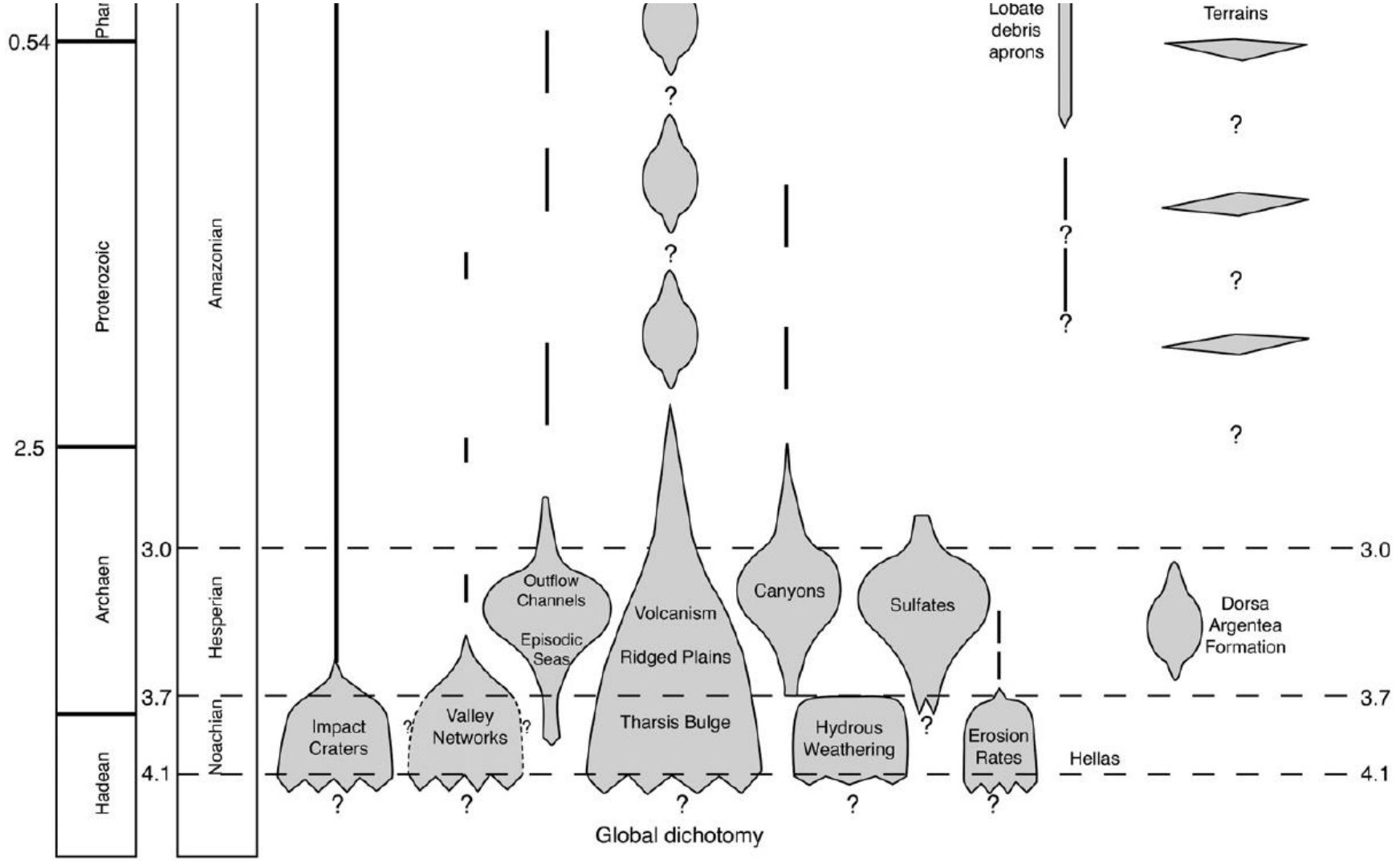
Curiosity

Mars

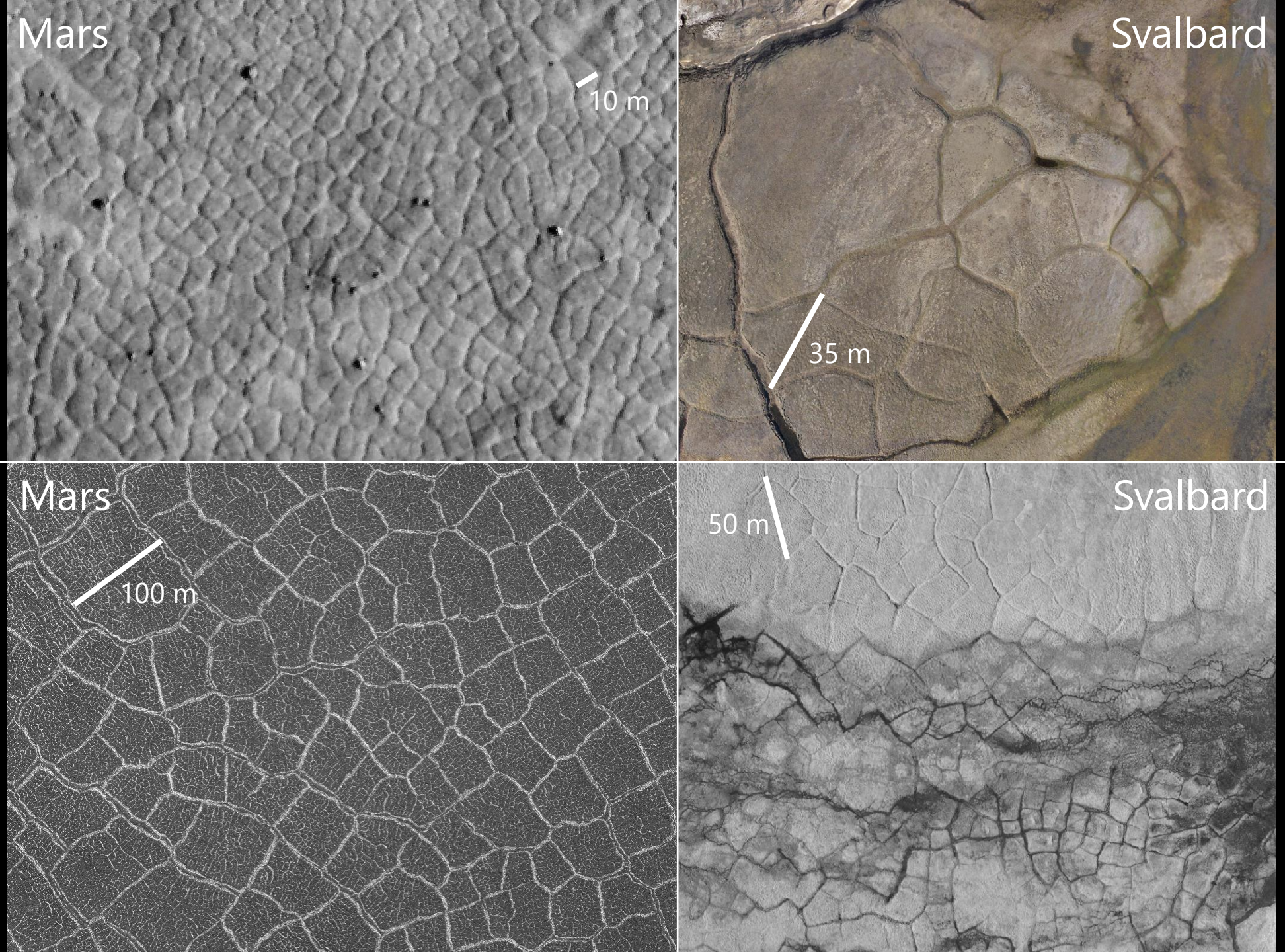
Earth

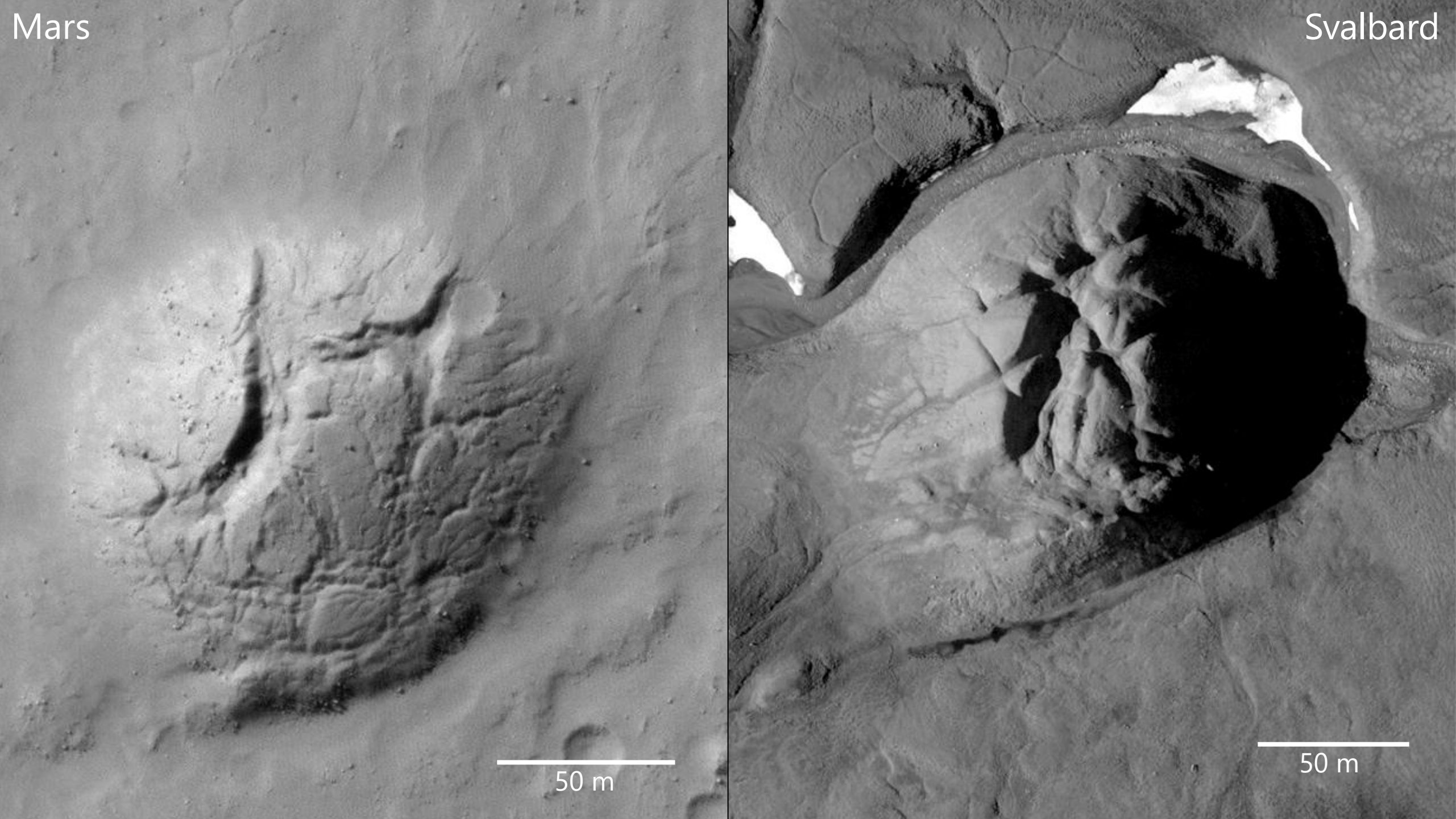
Geological history of Mars

But what has recently happened?



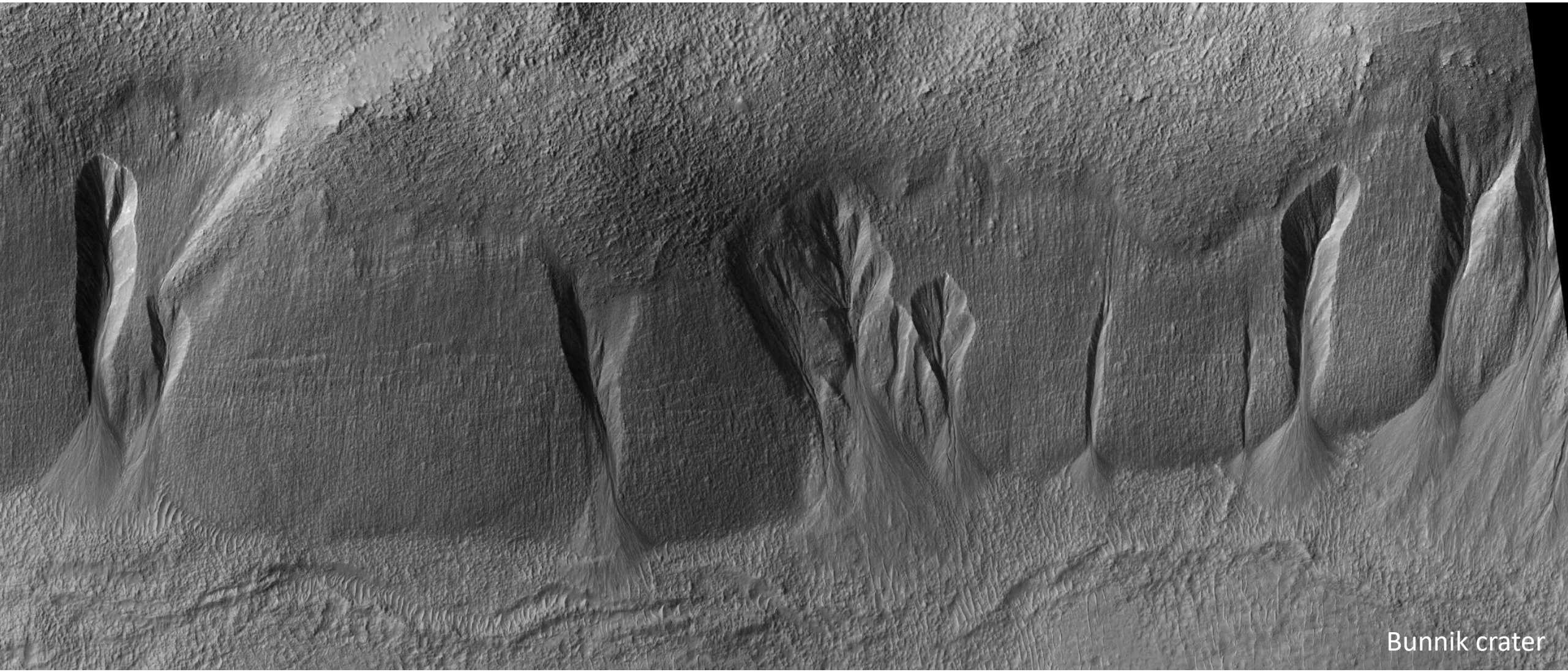
Permafrost


Mars
10 m
Svalbard
35 m
Mars
100 m
50 m
Svalbard


Mars
50 m
Svalbard
50 m

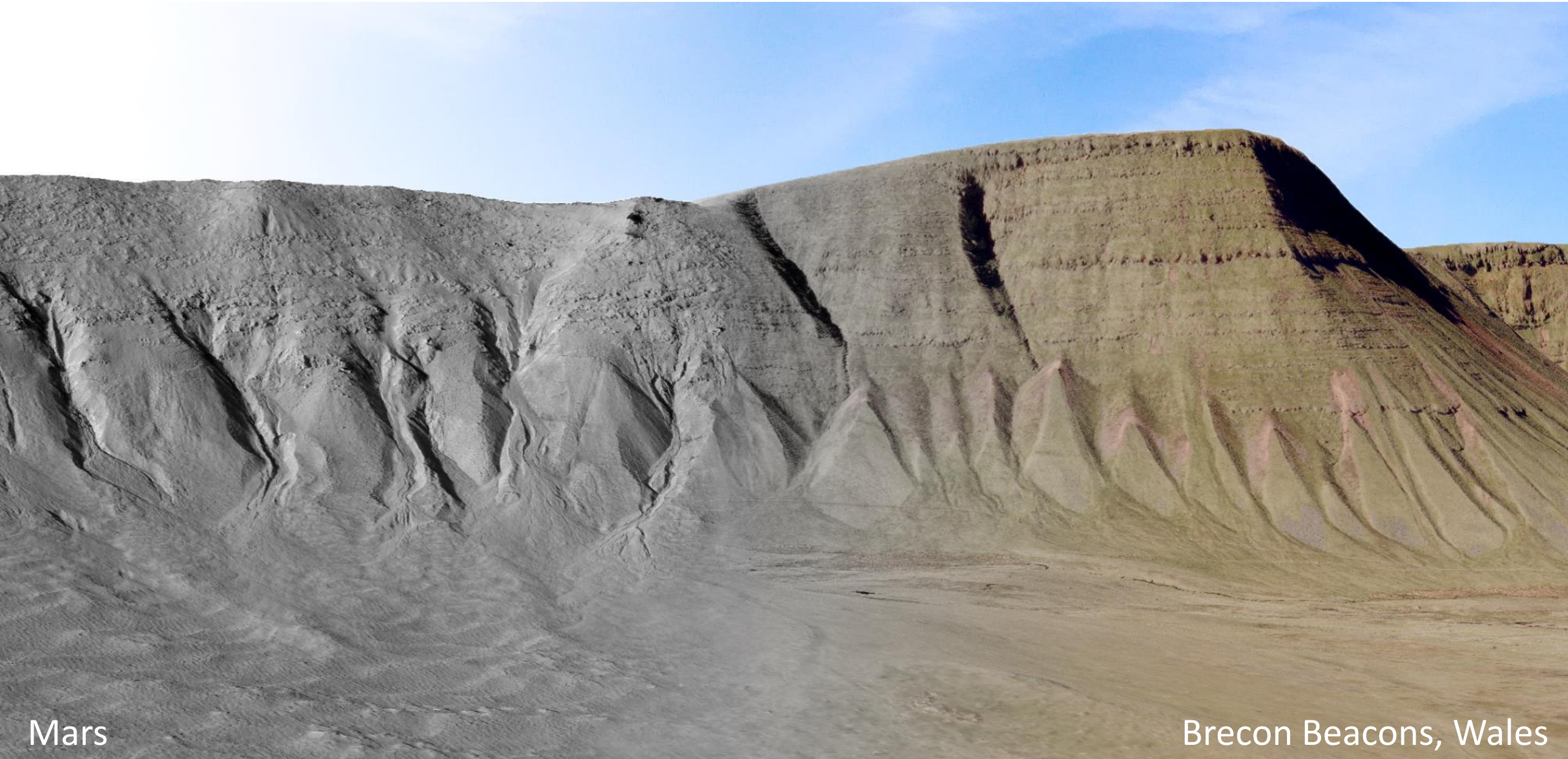
Gullies → Formed in the last few millions years

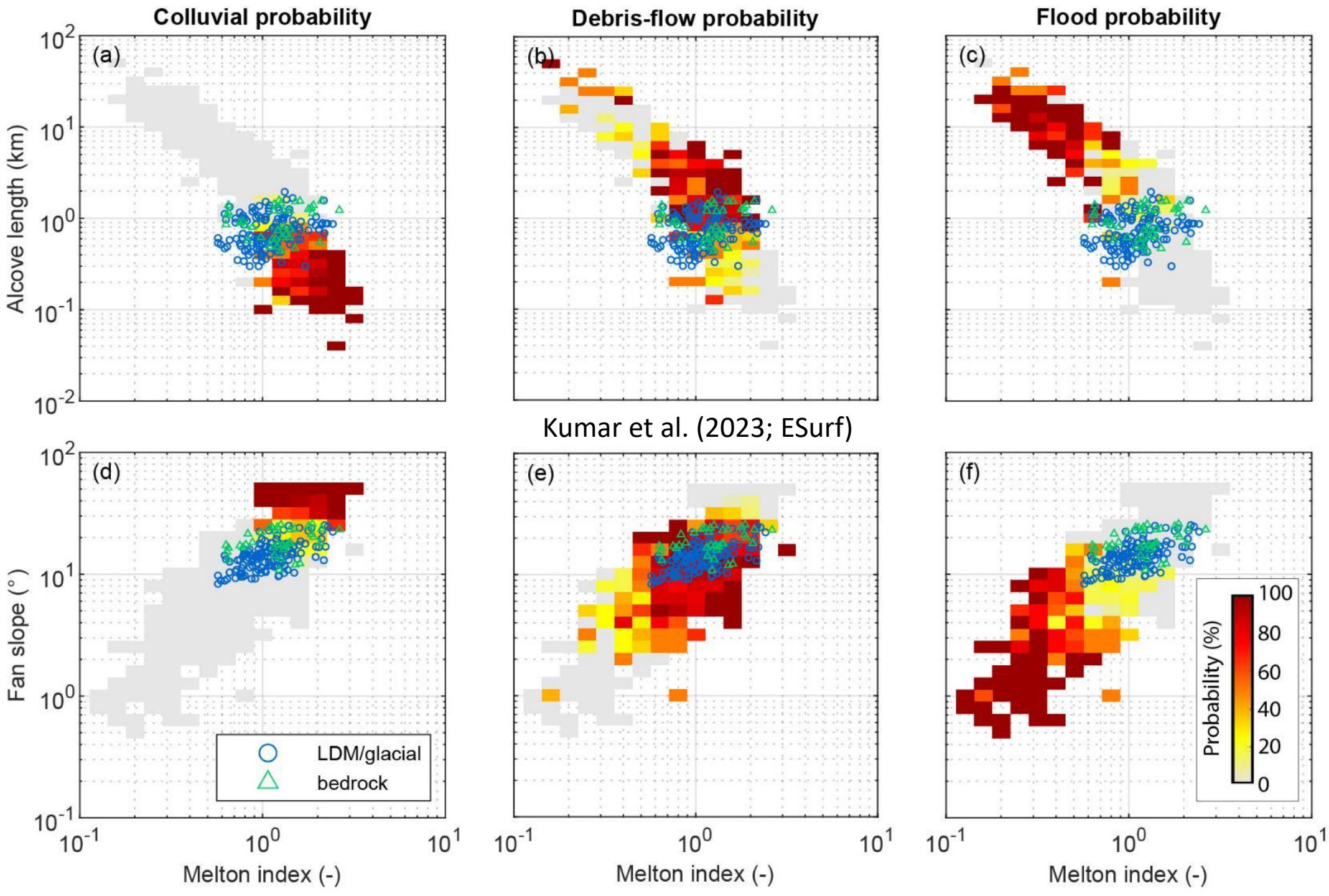
Was liquid water involved?



Martian gullies

Similar to debris-flow systems on Earth



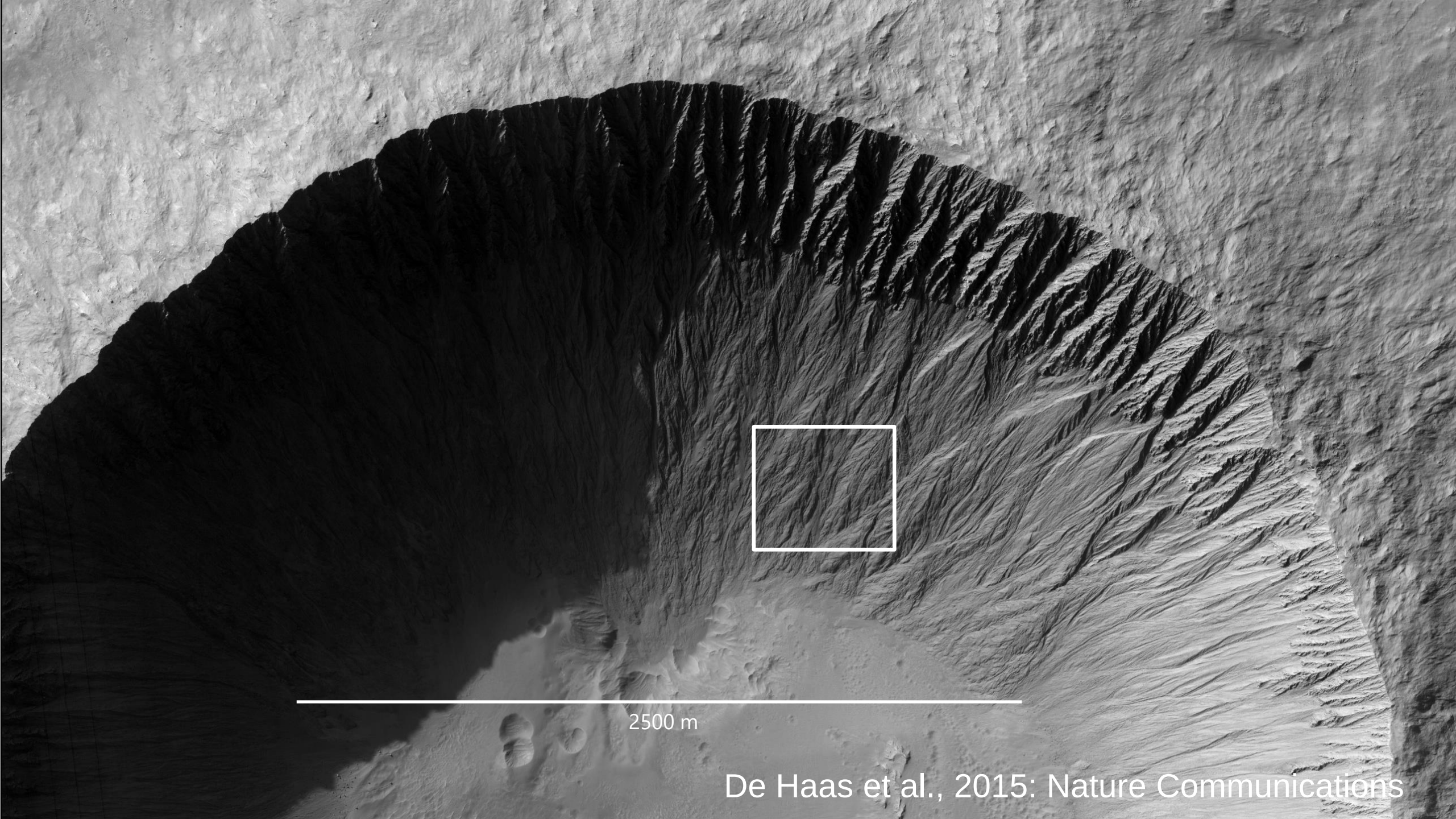


Kumar et al. (2023; ESurf)

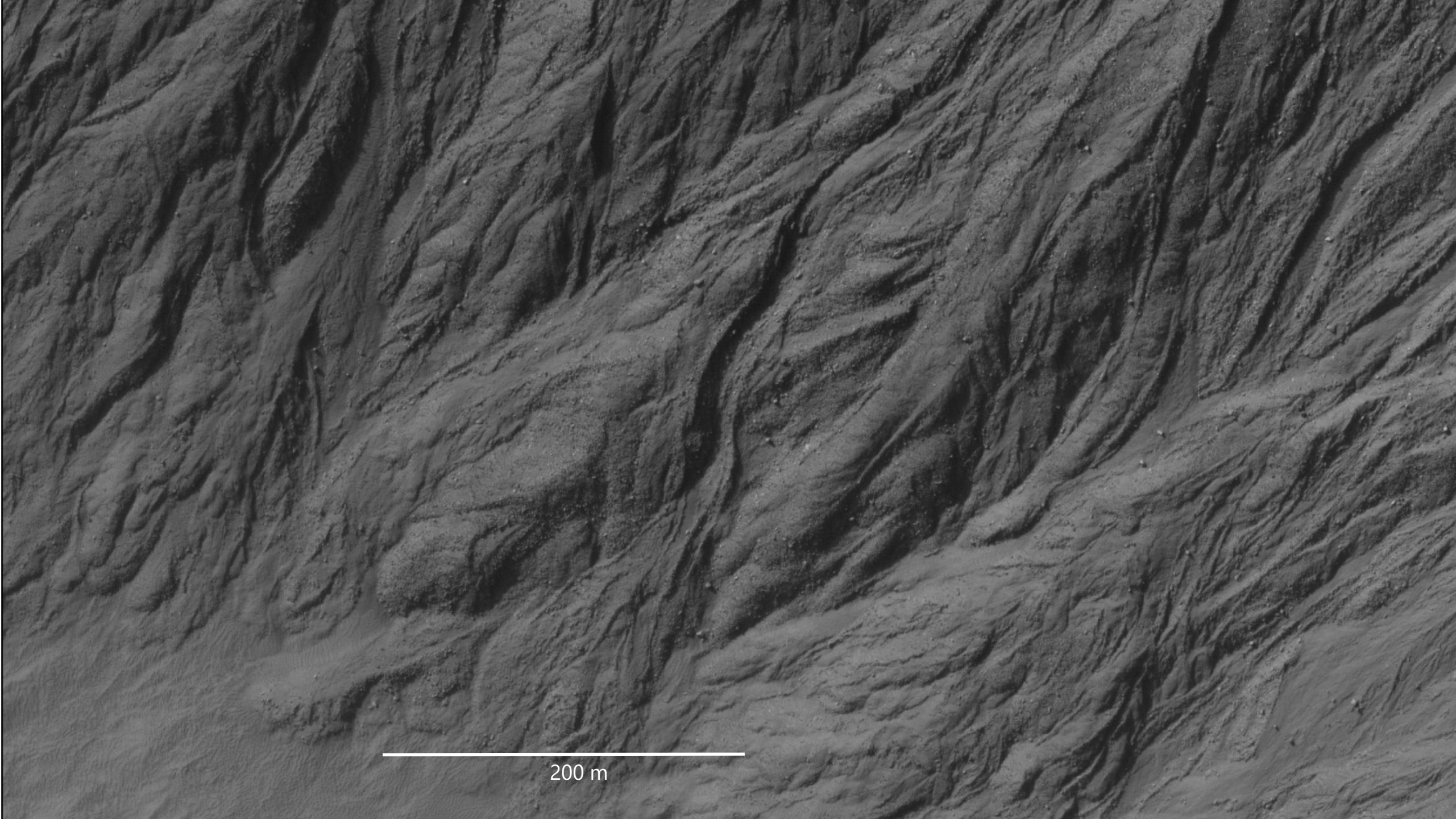

Svalbard


Atacama, Chile


Lobes
Levees
Atacama, Chile



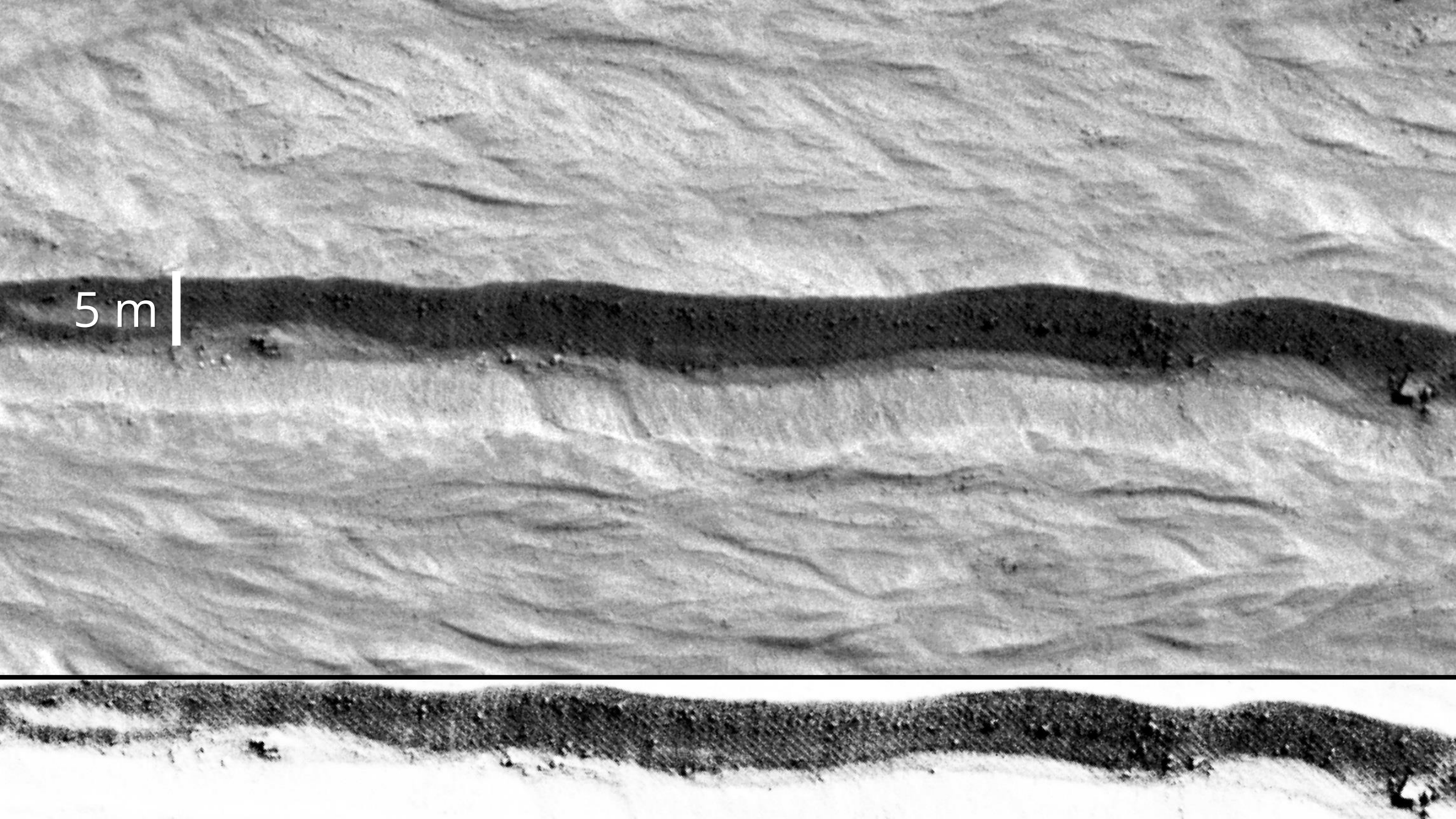
De Haas et al., 2015: Nature Communications

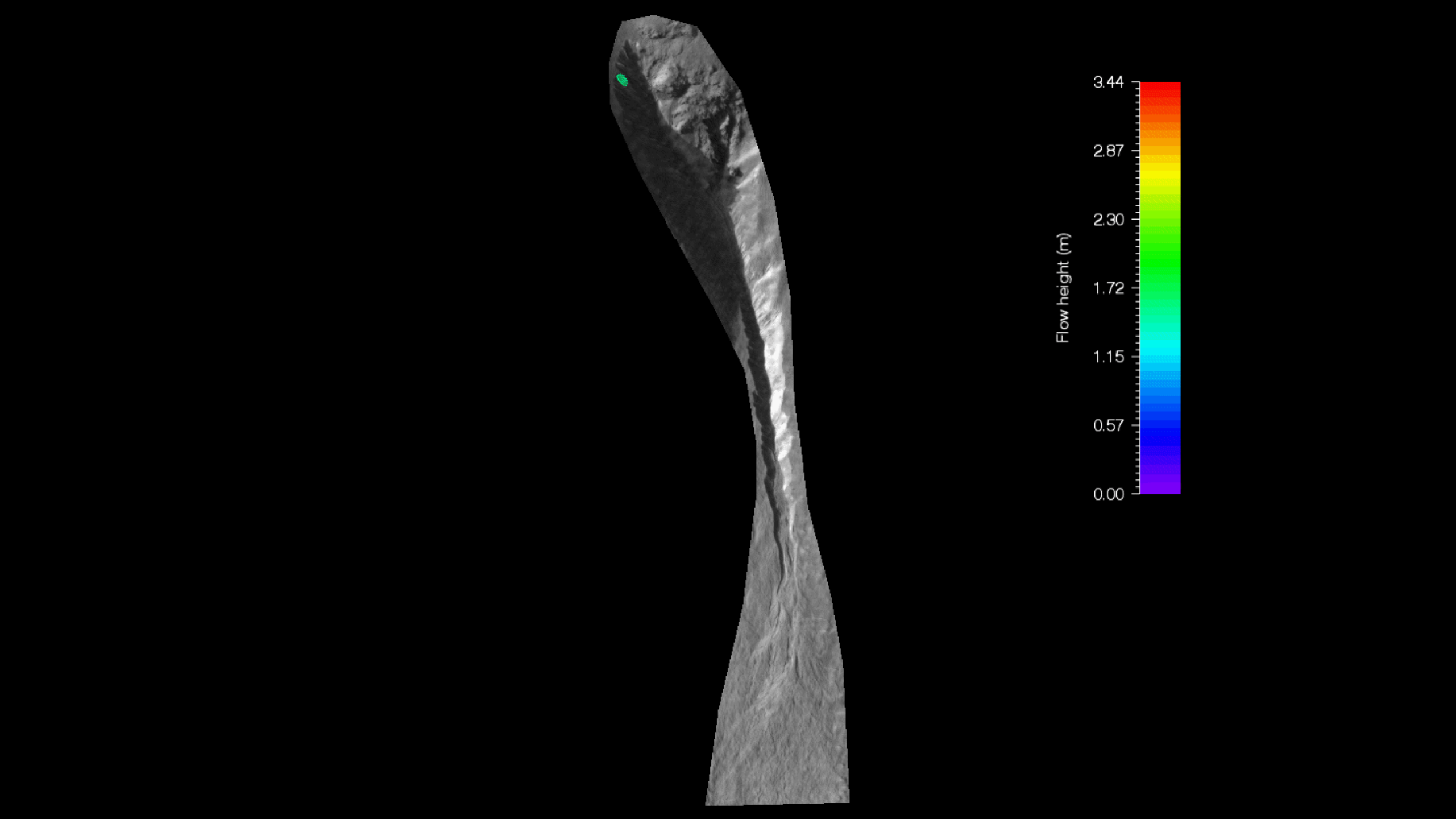

200 m

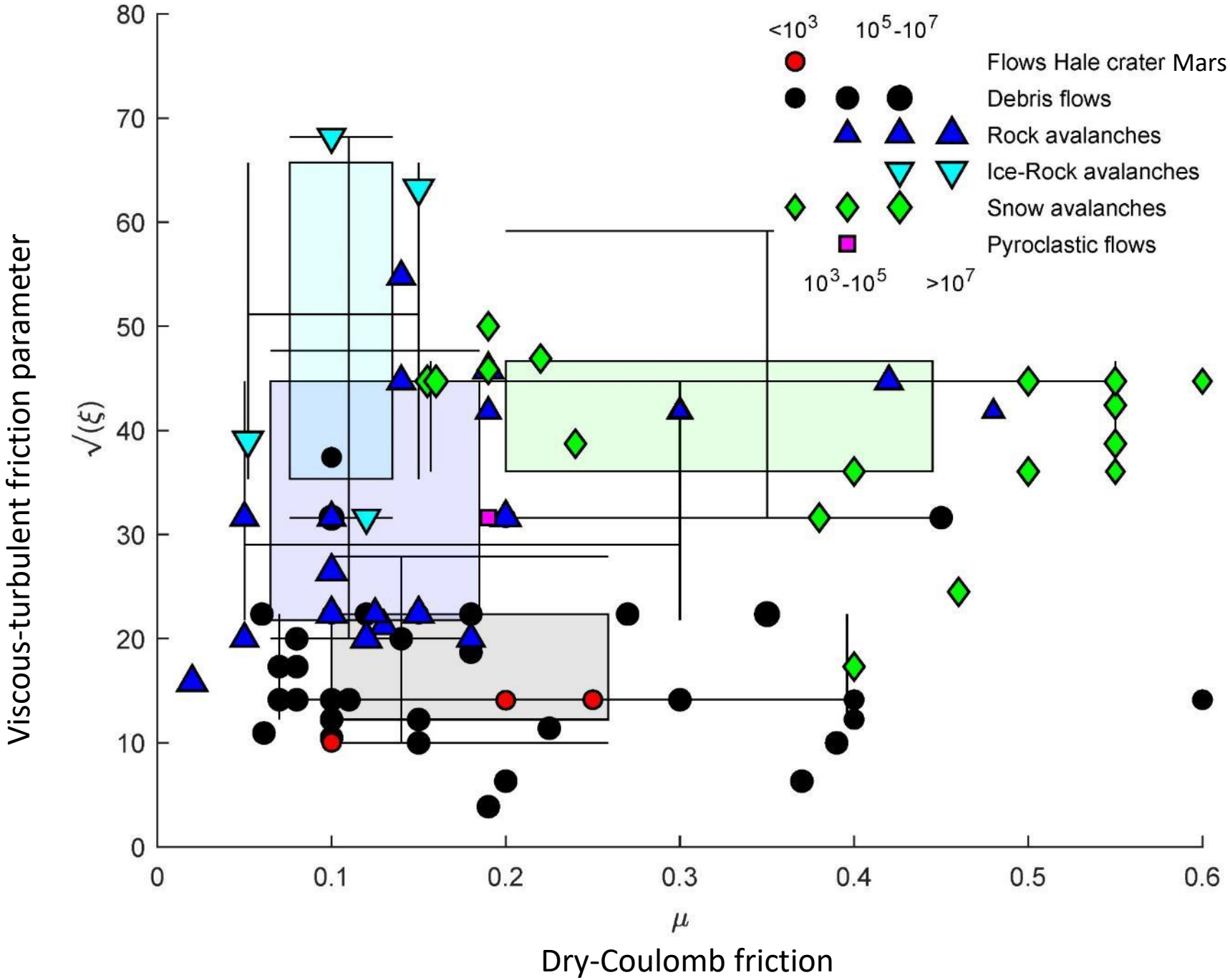

Atacama, Chile


Atacama, Chile


Atacama, Chile


5 m

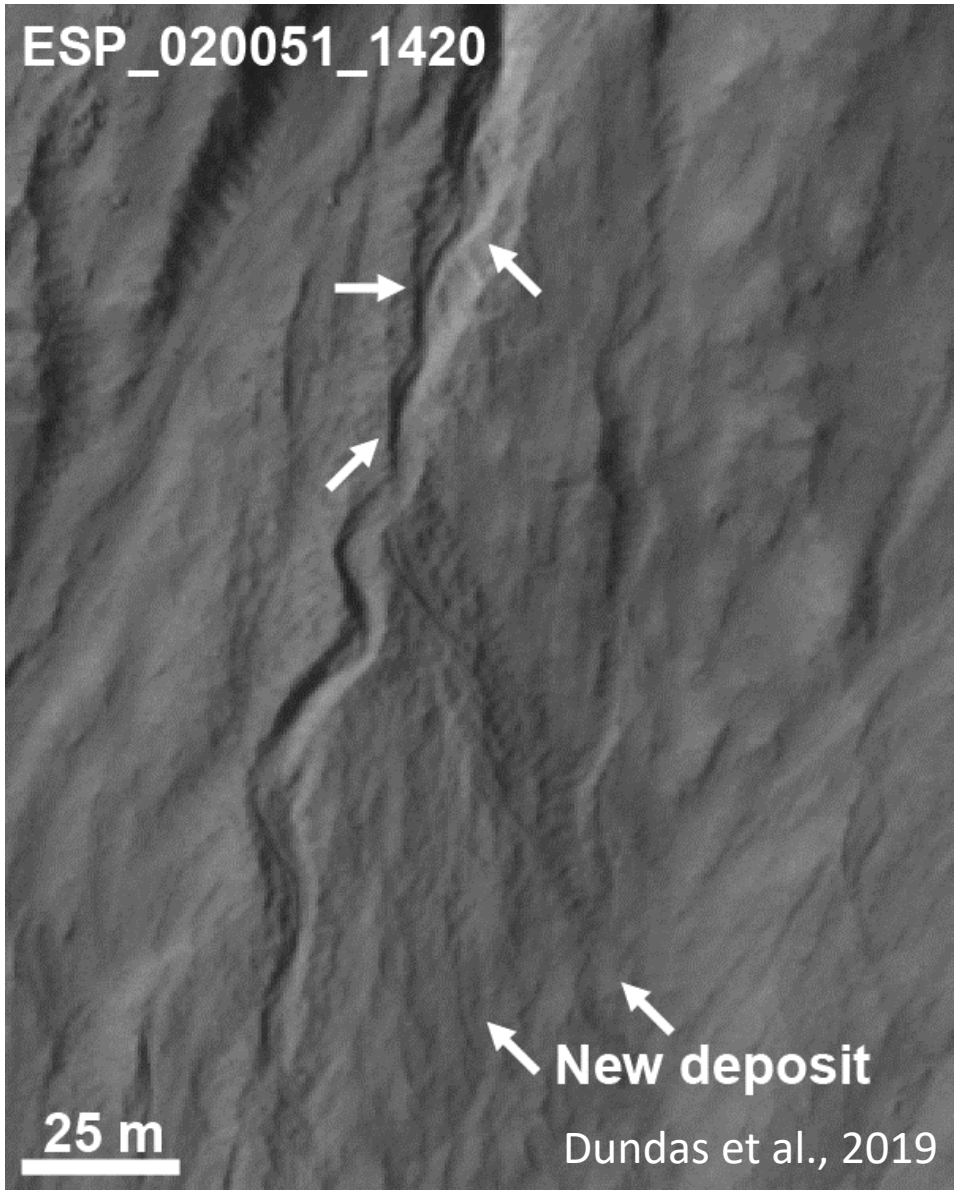

3.44
2.87
2.30
1.72
1.15
0.57
0.00
Flow height (m)

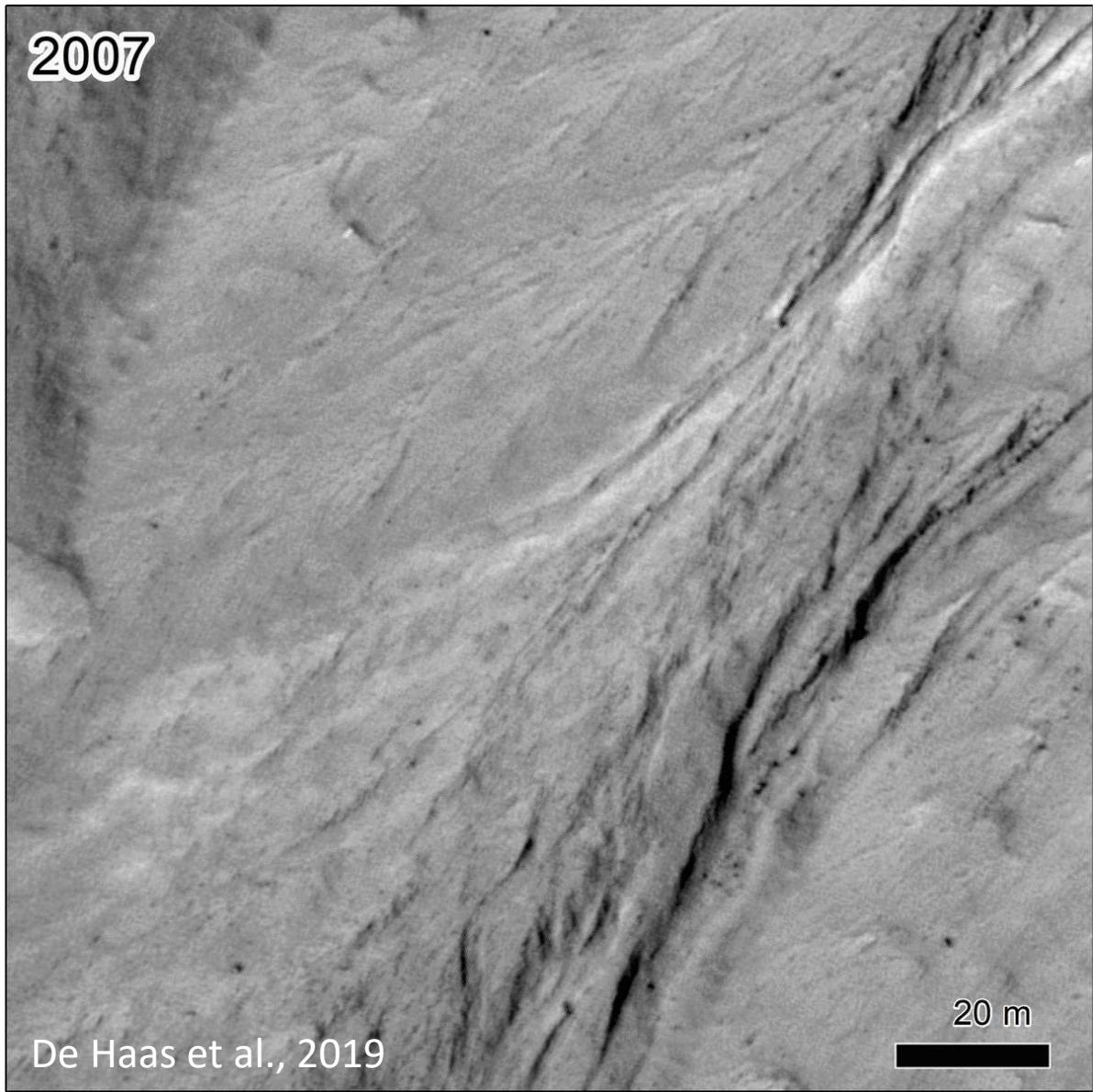


Friction similar to granular debris flows on Earth

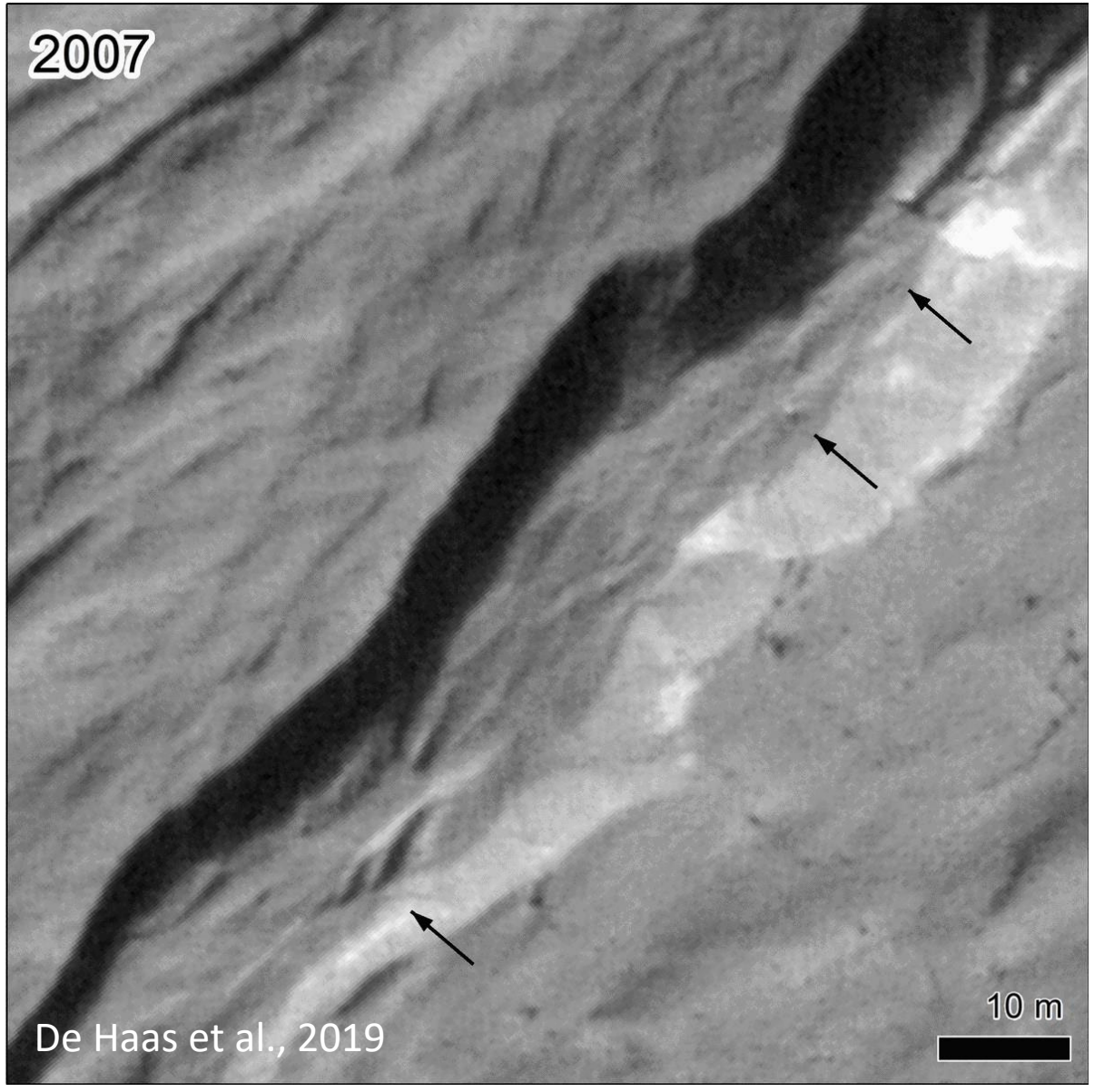
de Haas et al. JGR 2019

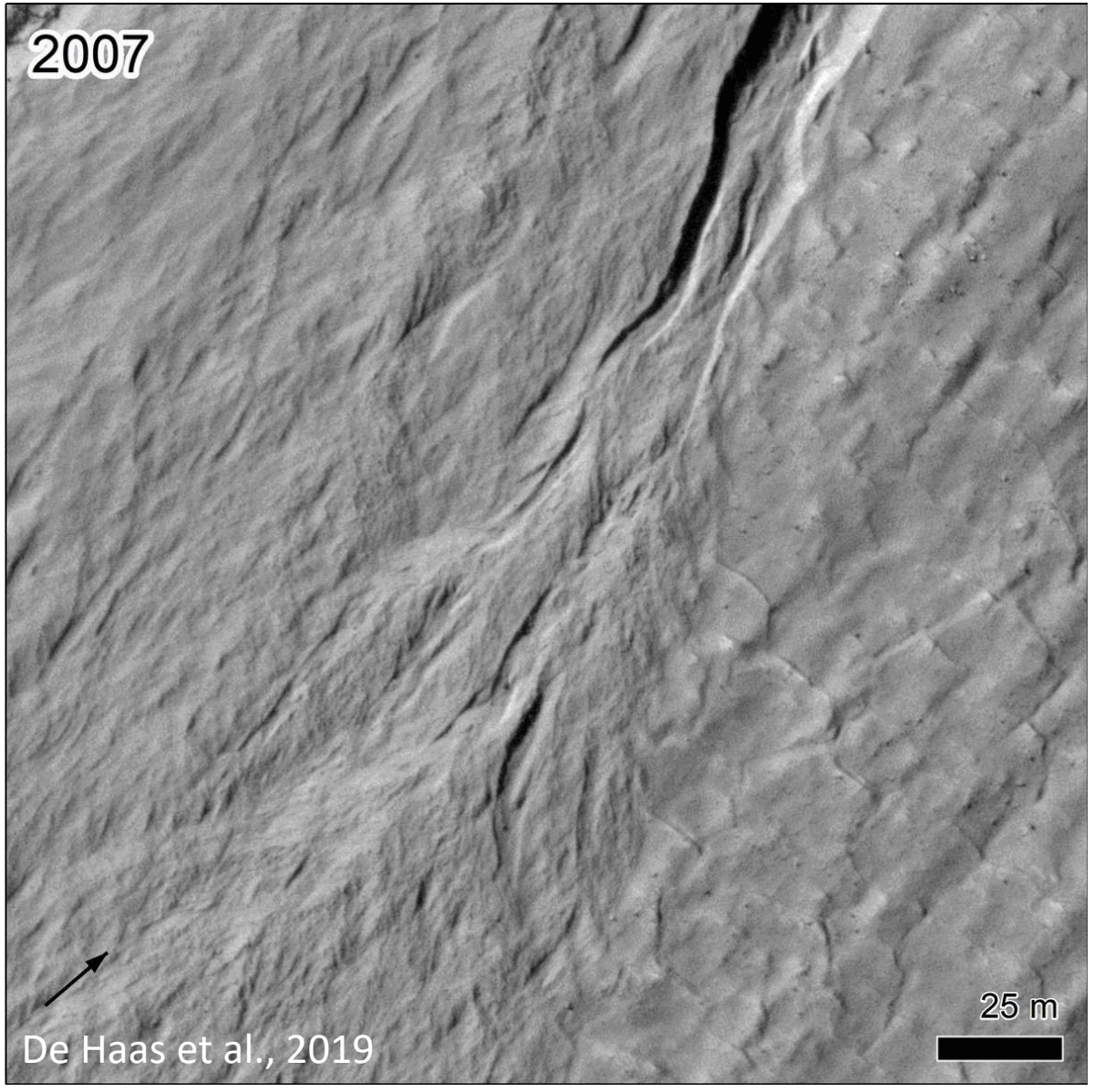
What we observe today!



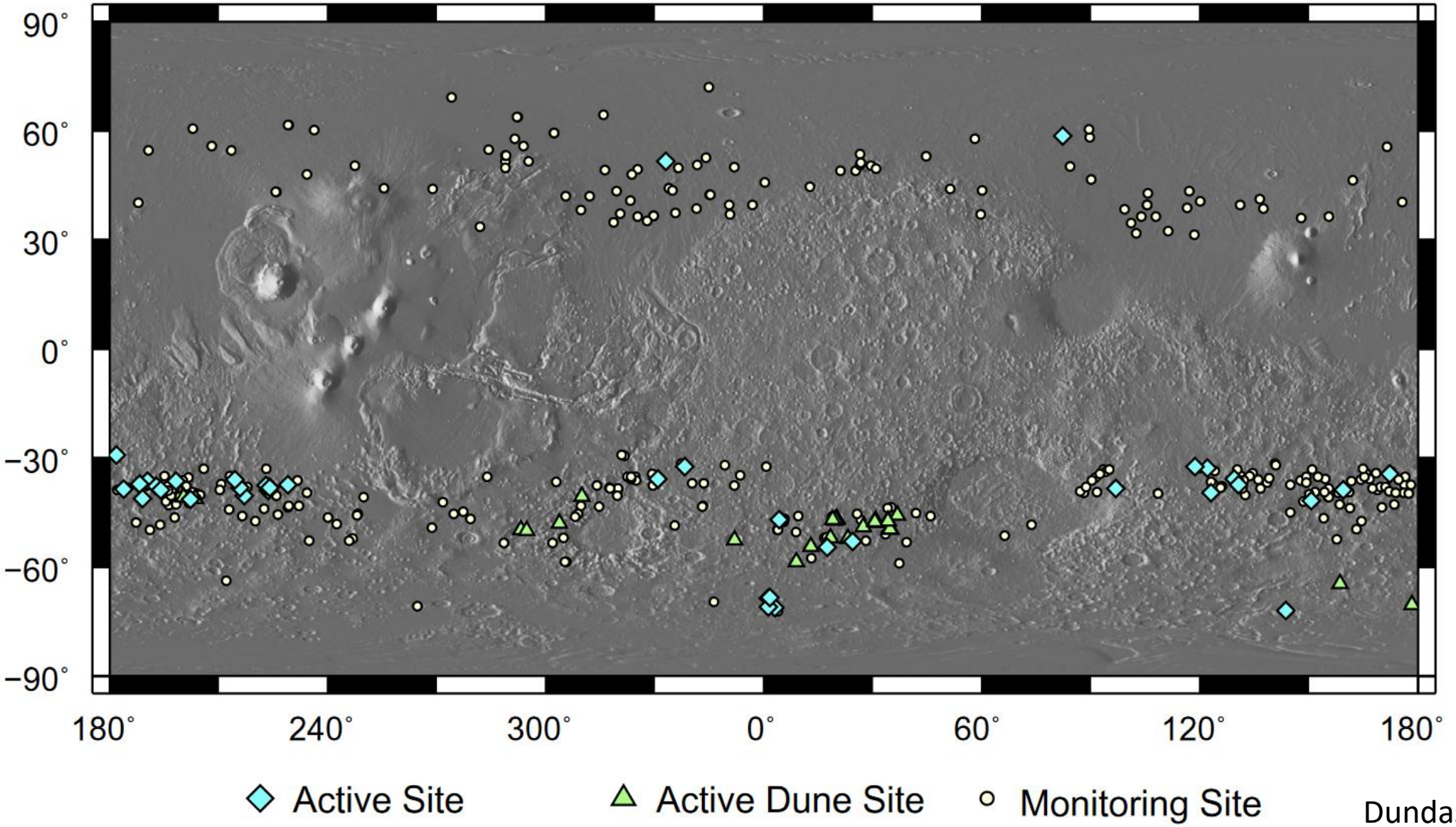


What we observe today!



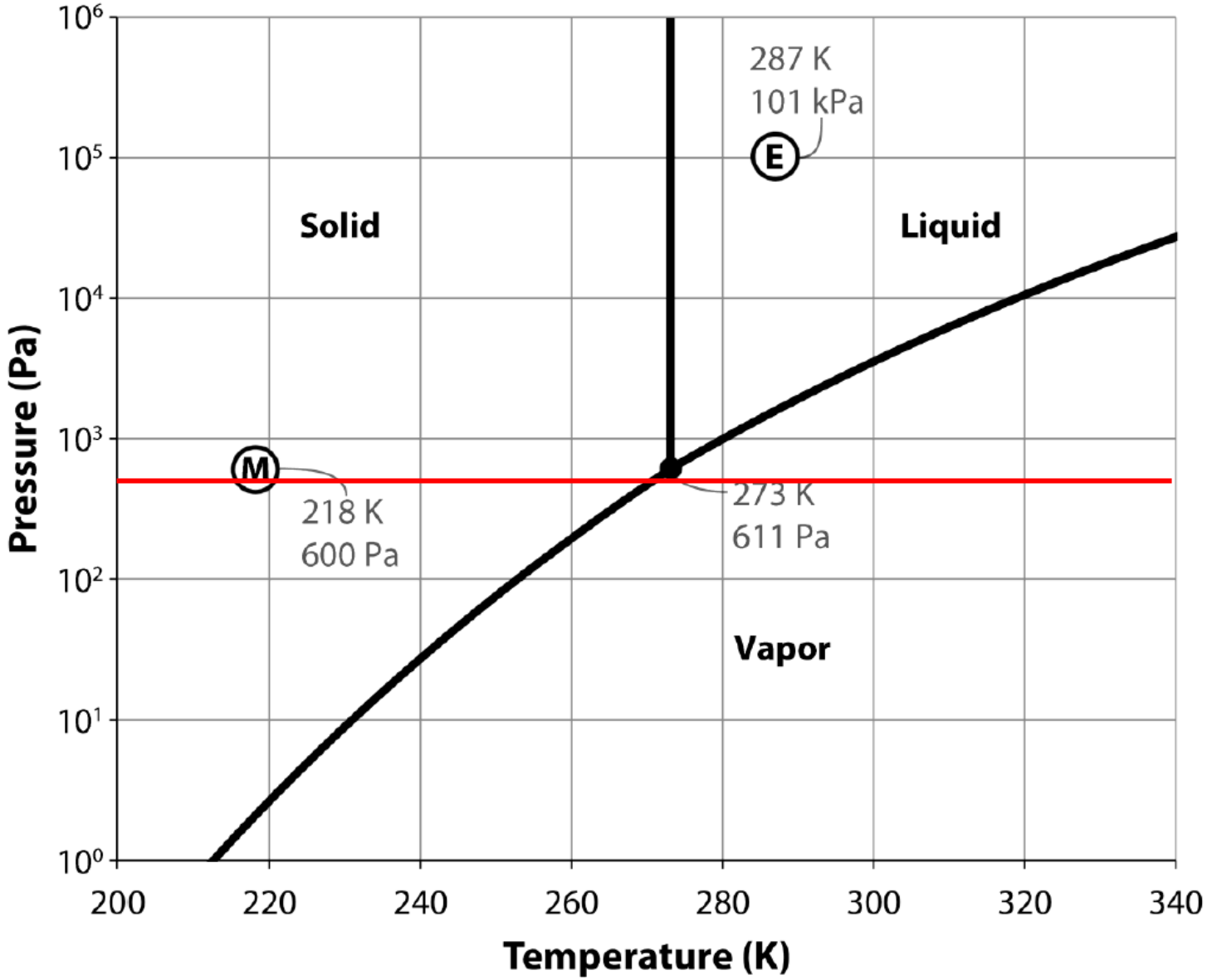


What we observe today!



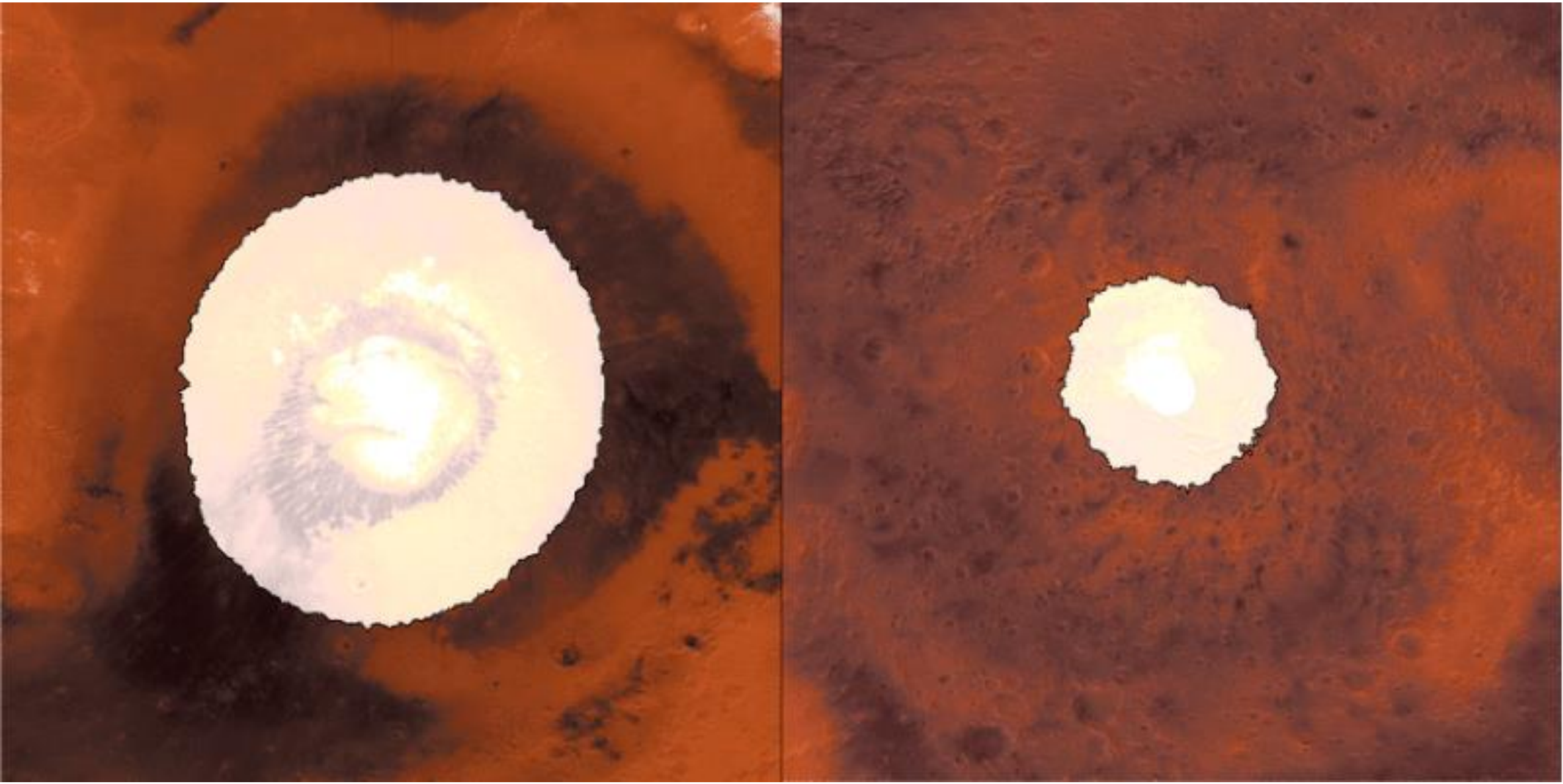
Dundas et al. 2019

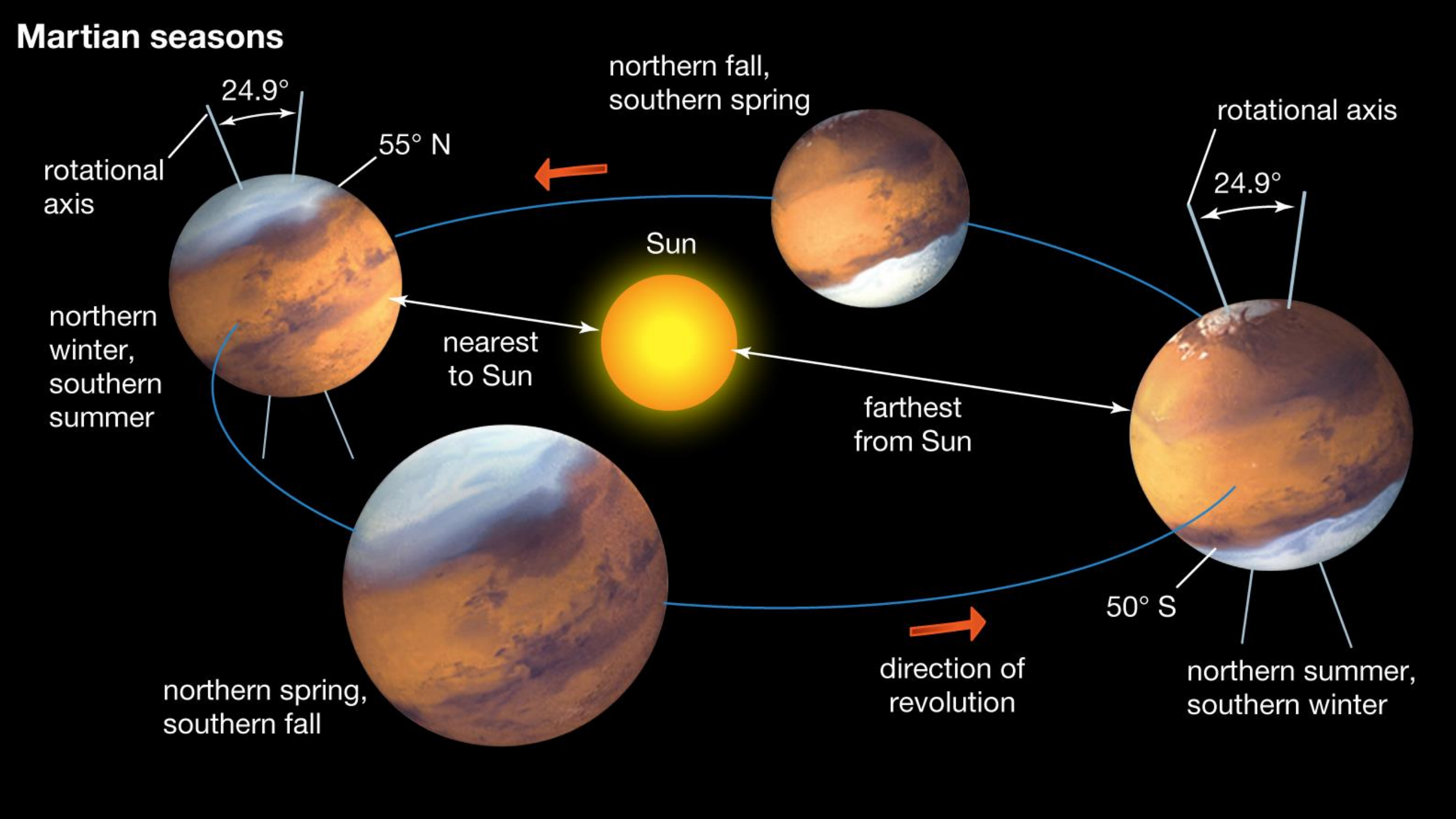
Mars today!


Pressure (Pa)
10^6
10^5
10^4
10^3
10^2
10^1
10^0
200
220
240
260
280
300
320
340
Temperature (K)
287 K
101 kPa
E
Solid
Liquid
M
218 K
600 Pa
273 K
611 Pa
Vapor

if it walks like a duck, quacks like a duck, and acts like a duck, it could be a dragon doing a duck impersonation.

someecards
user card




Martian seasons
24.9°
55° N
rotational axis
northern fall, southern spring
rotational axis
24.9°
Sun
northern winter, southern summer
nearest to Sun
farthest from Sun
50° S
northern spring, southern fall
direction of revolution
northern summer, southern winter

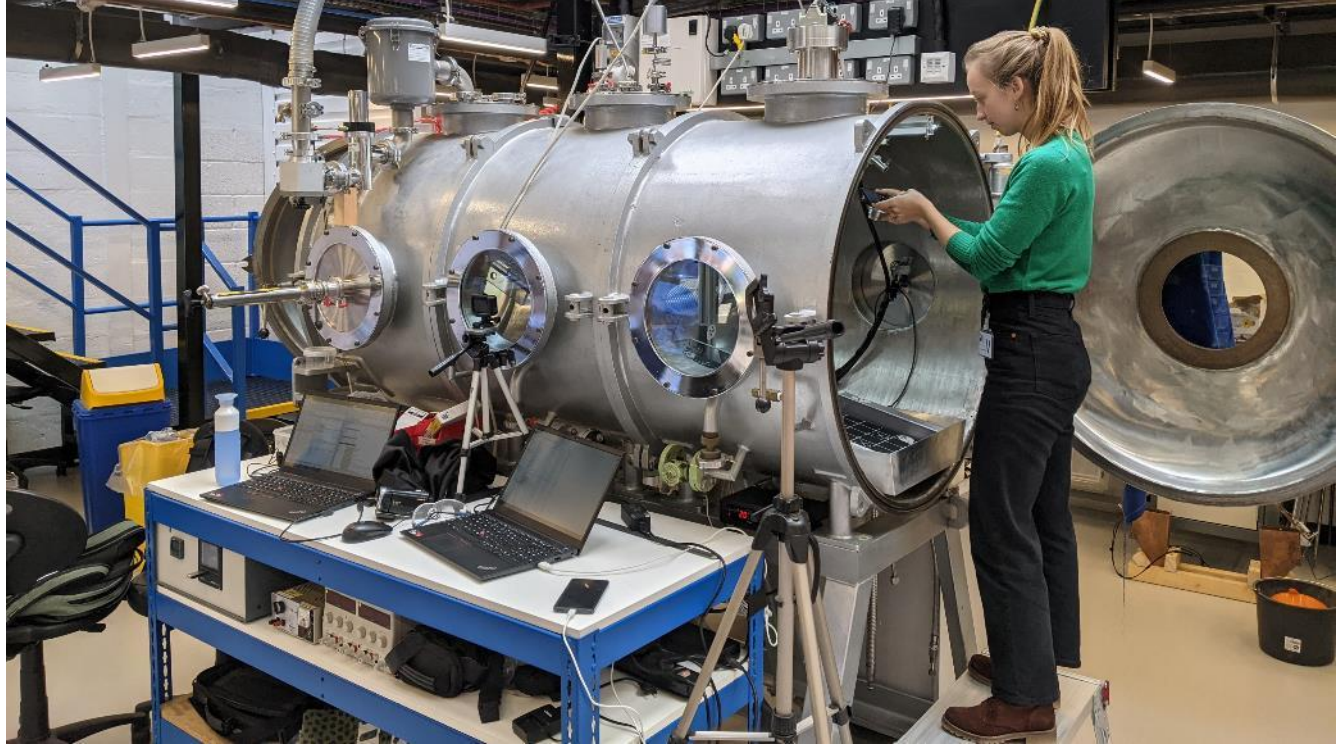
CO_2 ice in gullies

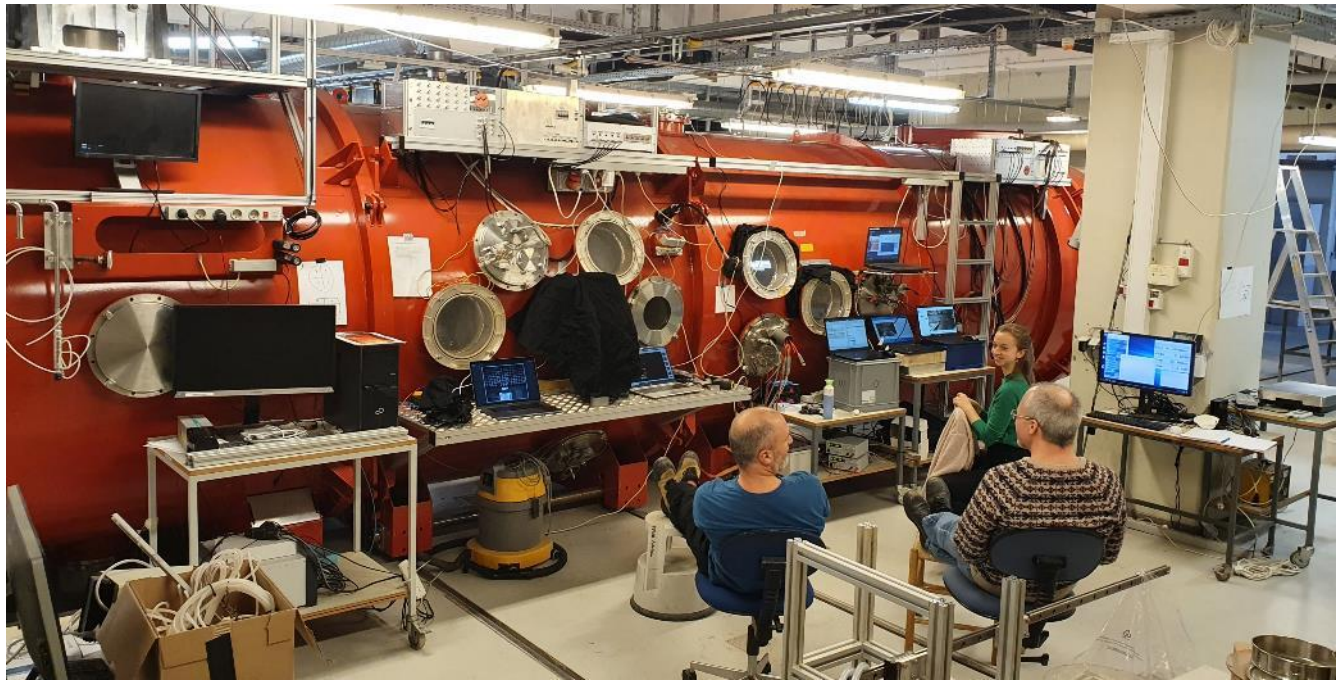
Sisyphi Planum, Mars

Mount Semeru – Indonesia
End of 2022

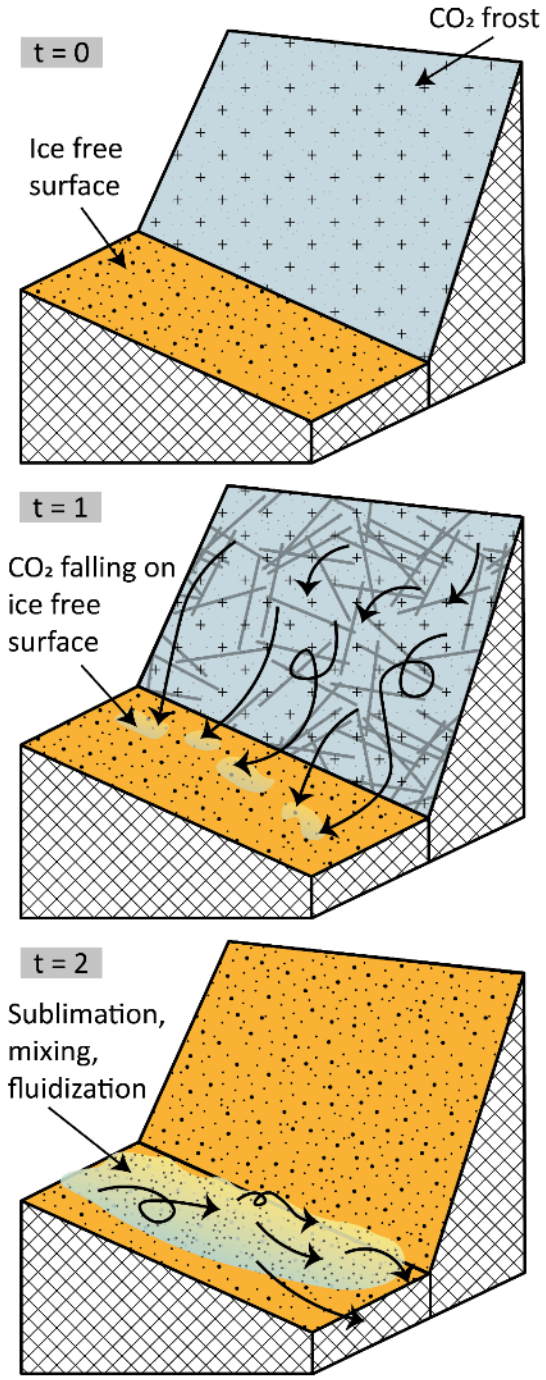
The Open University

AARHUS UNIVERSITY



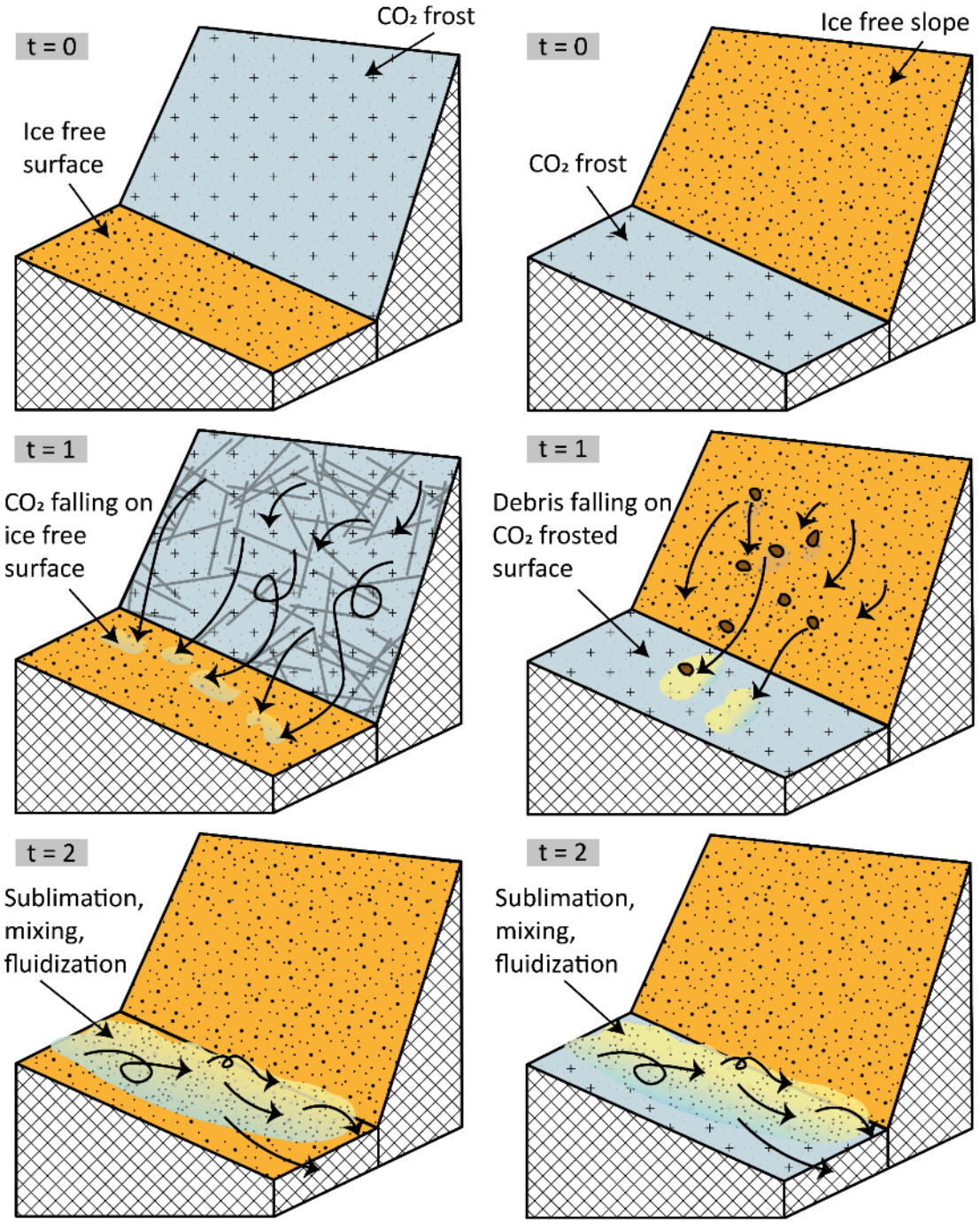


Hypothesis 1:
Ice-sand mixtures on warm sediment bed



Roelofs et al. In Prep

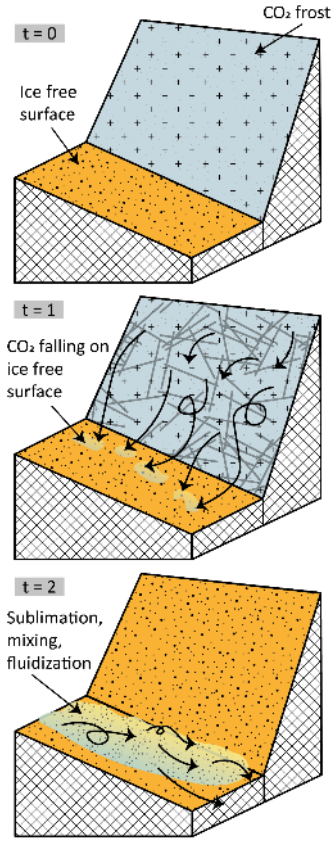
Hypothesis 1:
Ice-sand mixtures on warm sediment bed



Hypothesis 2:
Warm sediment on ice-covered bed

Mass flow on Earth – mechanism 1

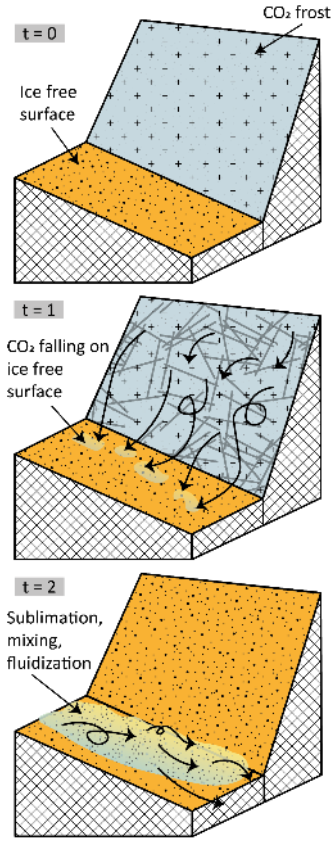
Earth – 300 gr CO_2 – 1 kg sand – ice-free bed



Roelofs et al. In Prep

Mass flow on Mars – mechanism 1

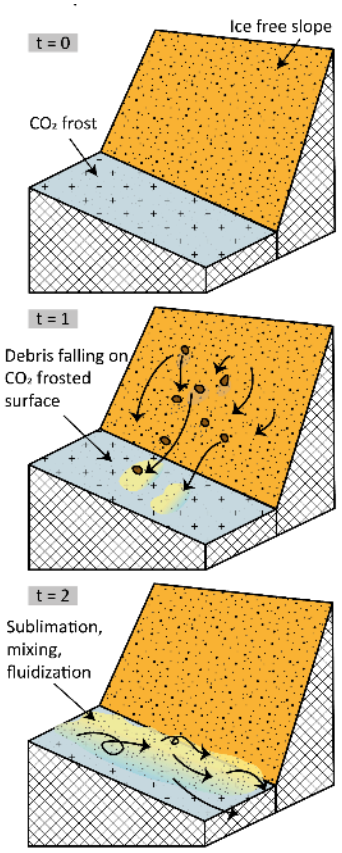
Mars – 300 gr CO_2 – 1 kg sand – ice-free bed



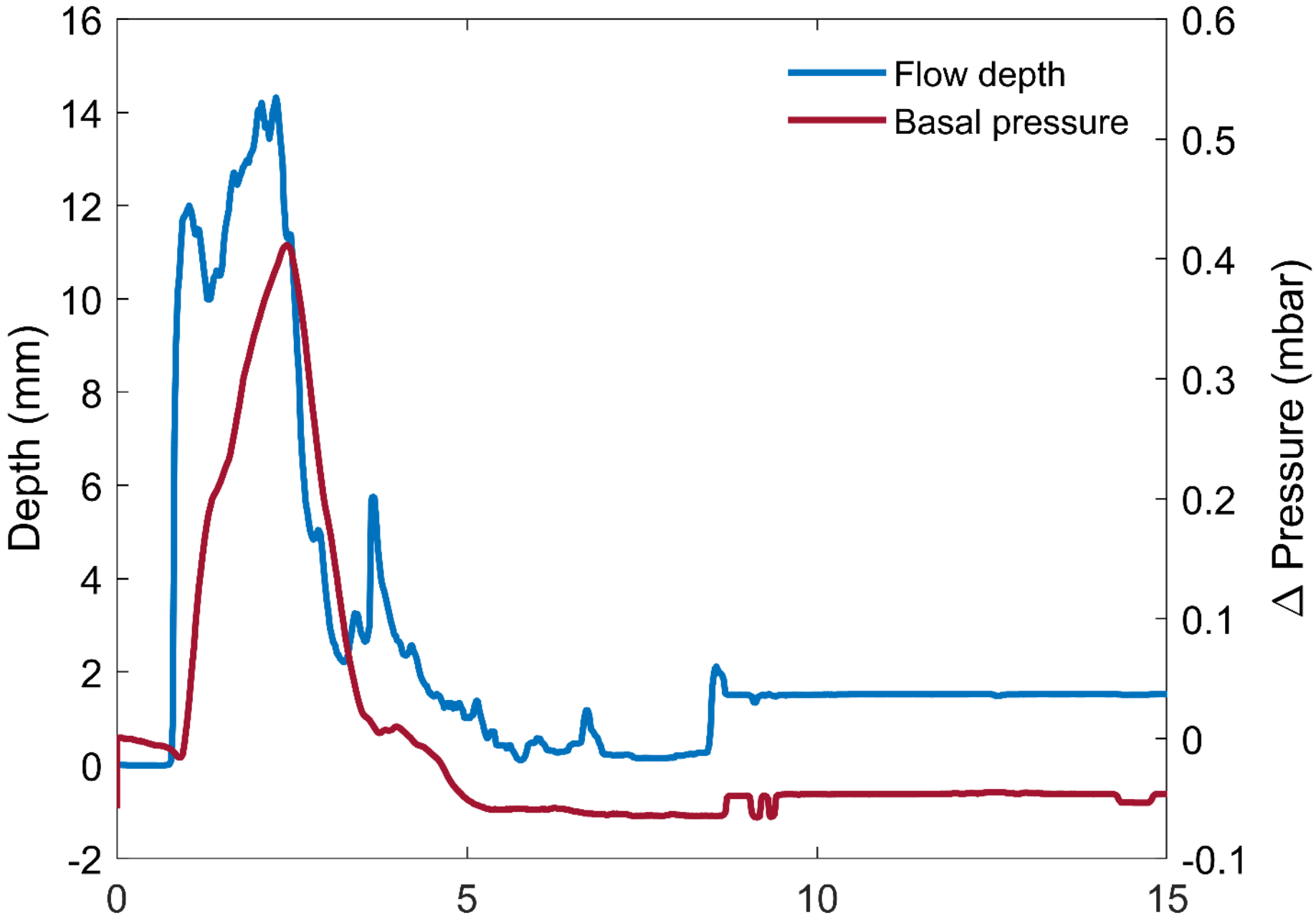
Roelofs et al. In Prep

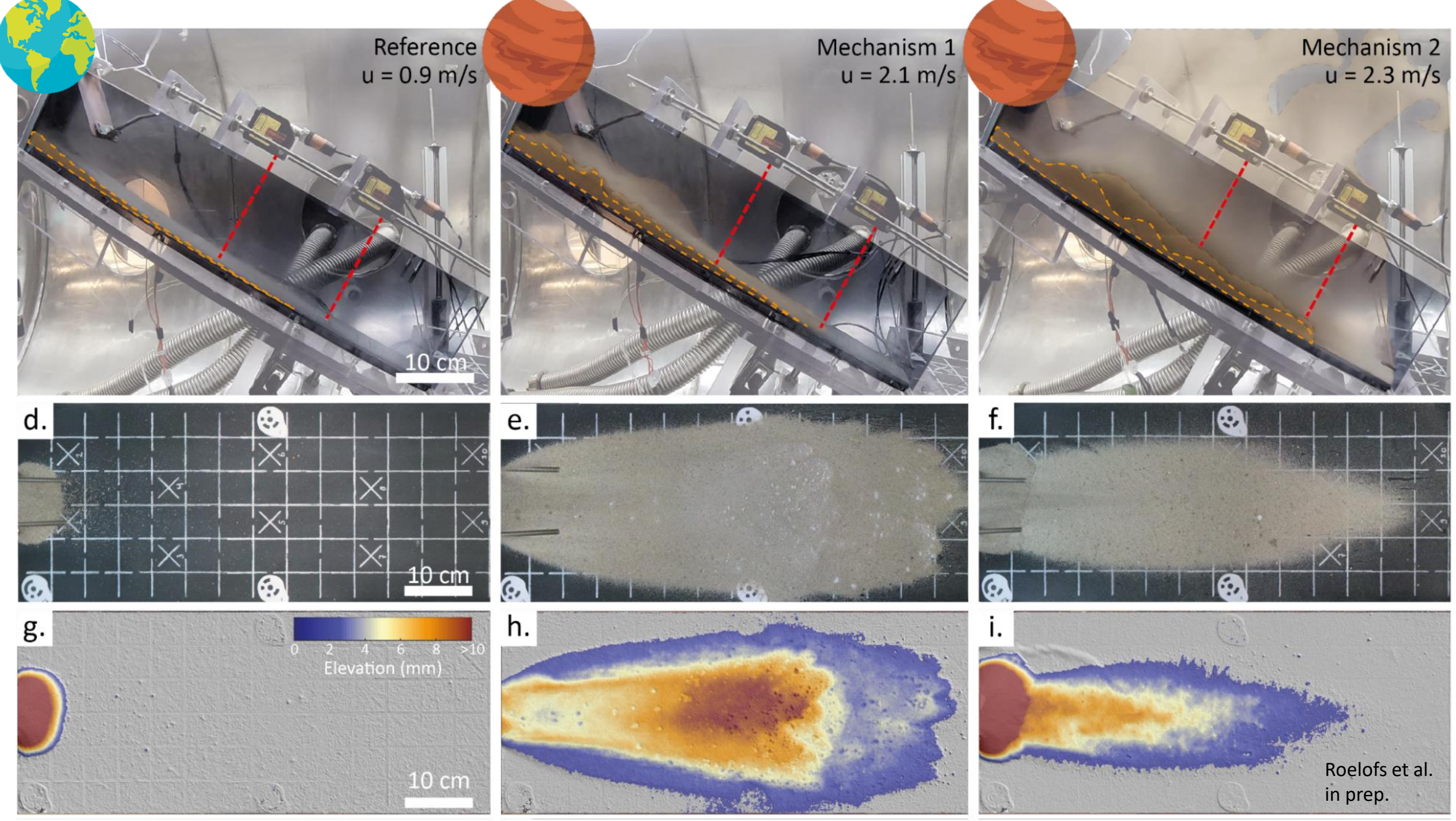
Mass flow on Mars – mechanism 2

Mars –1 kg sand – CO_2 ice on the bed

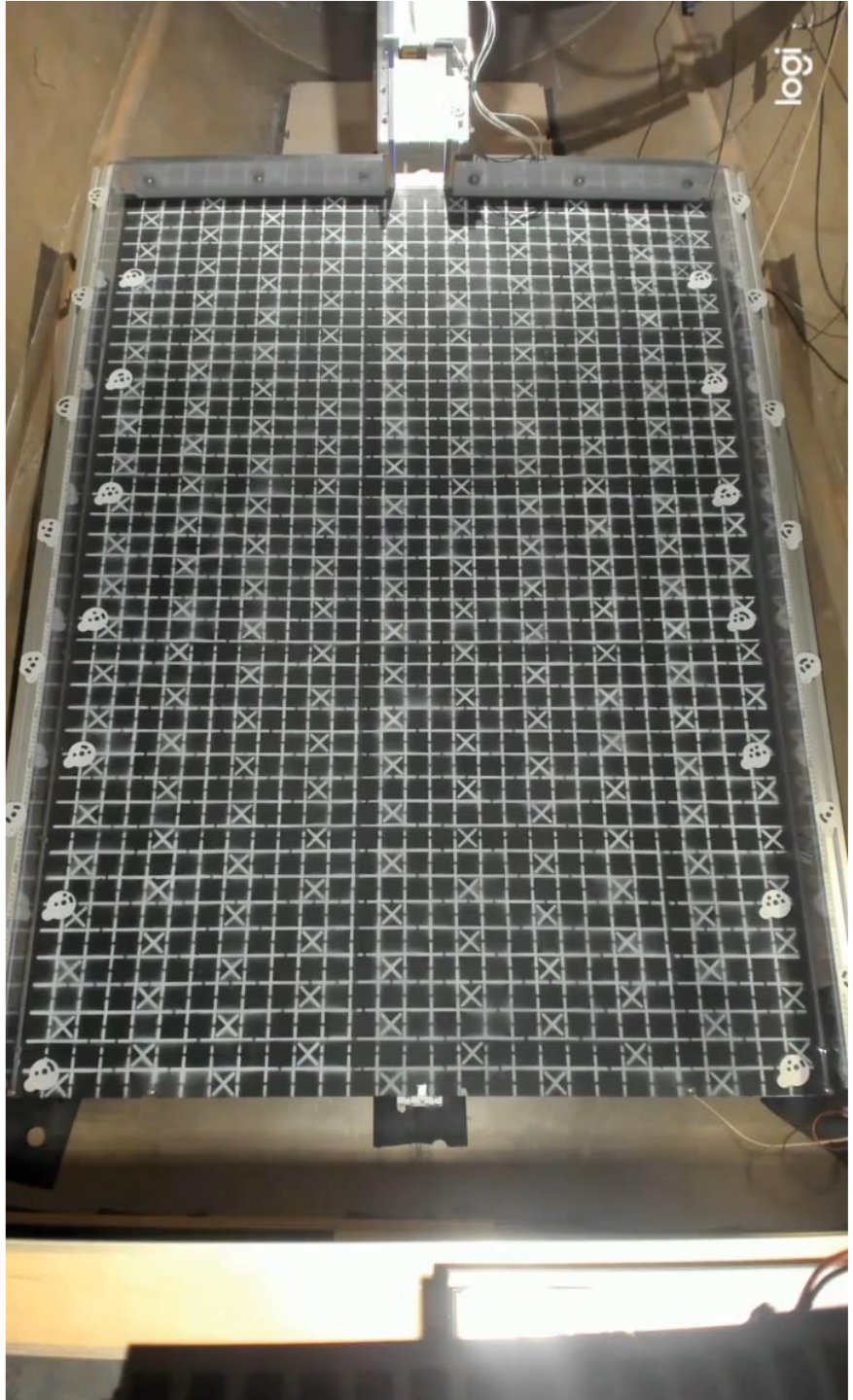


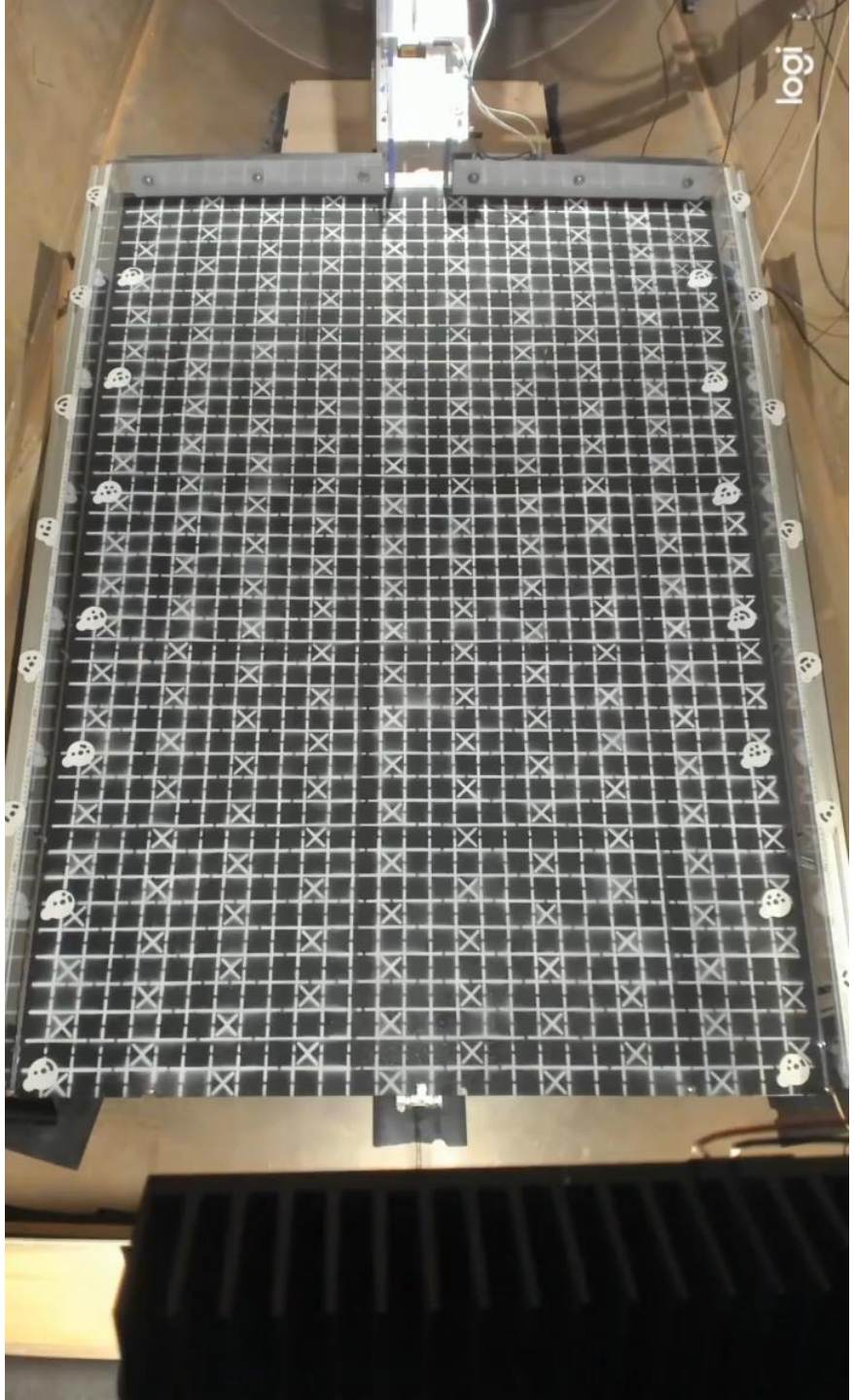
Roelofs et al. In Prep


Flow depth
Basal pressure
Depth (mm)
Δ Pressure (mbar)
16
14
12
10
8
6
4
2
0
-2
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
0
5
10
15

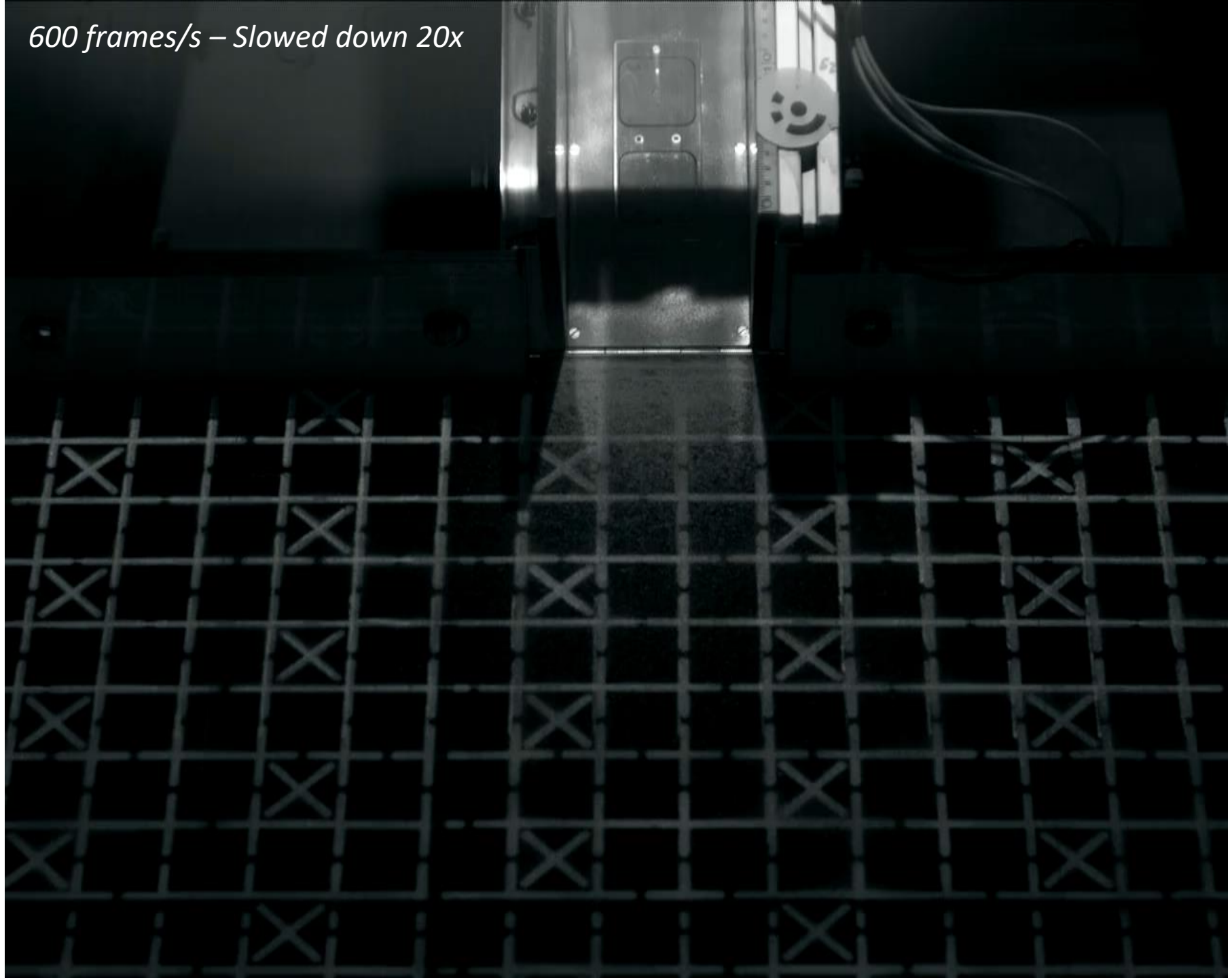

Reference
u = 0.9 m/s
Mechanism 1
u = 2.1 m/s
Mechanism 2
u = 2.3 m/s
10 cm
d.
e.
f.
10 cm
g.
0 2 4 6 8 >10
Elevation (mm)
h.
i.
10 cm
Roelofs et al.
in prep.

Mars: with CO_2

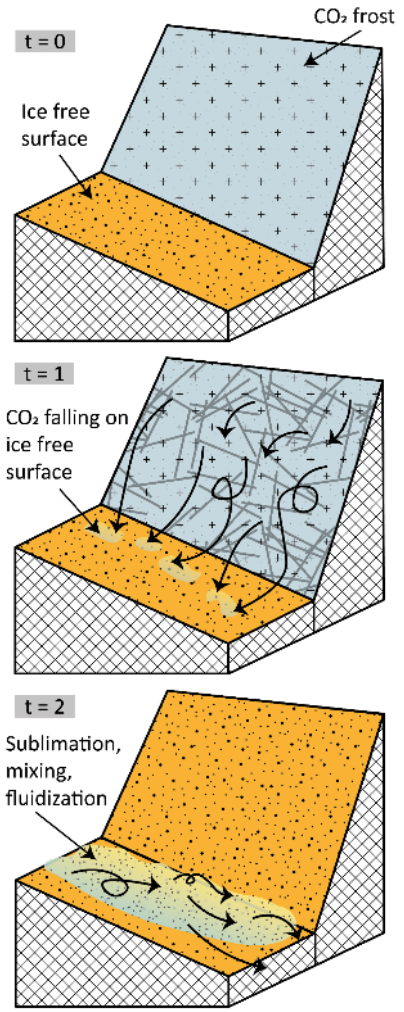


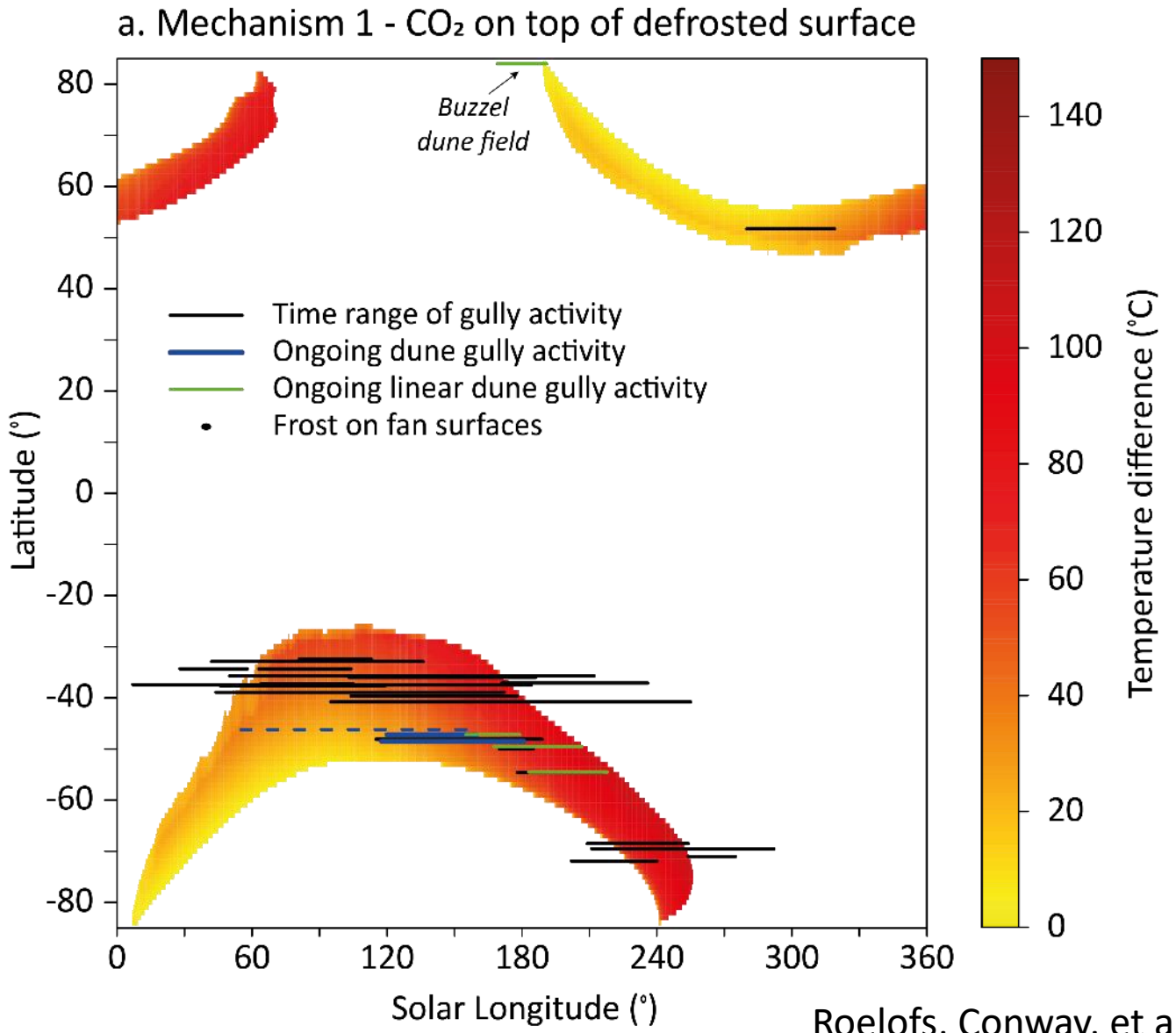


Mars: without CO_2


600 frames/s – Slowed down 20x

Climate model reproduces observed activity





Roelofs, Conway, et al, In Review

Conclusions

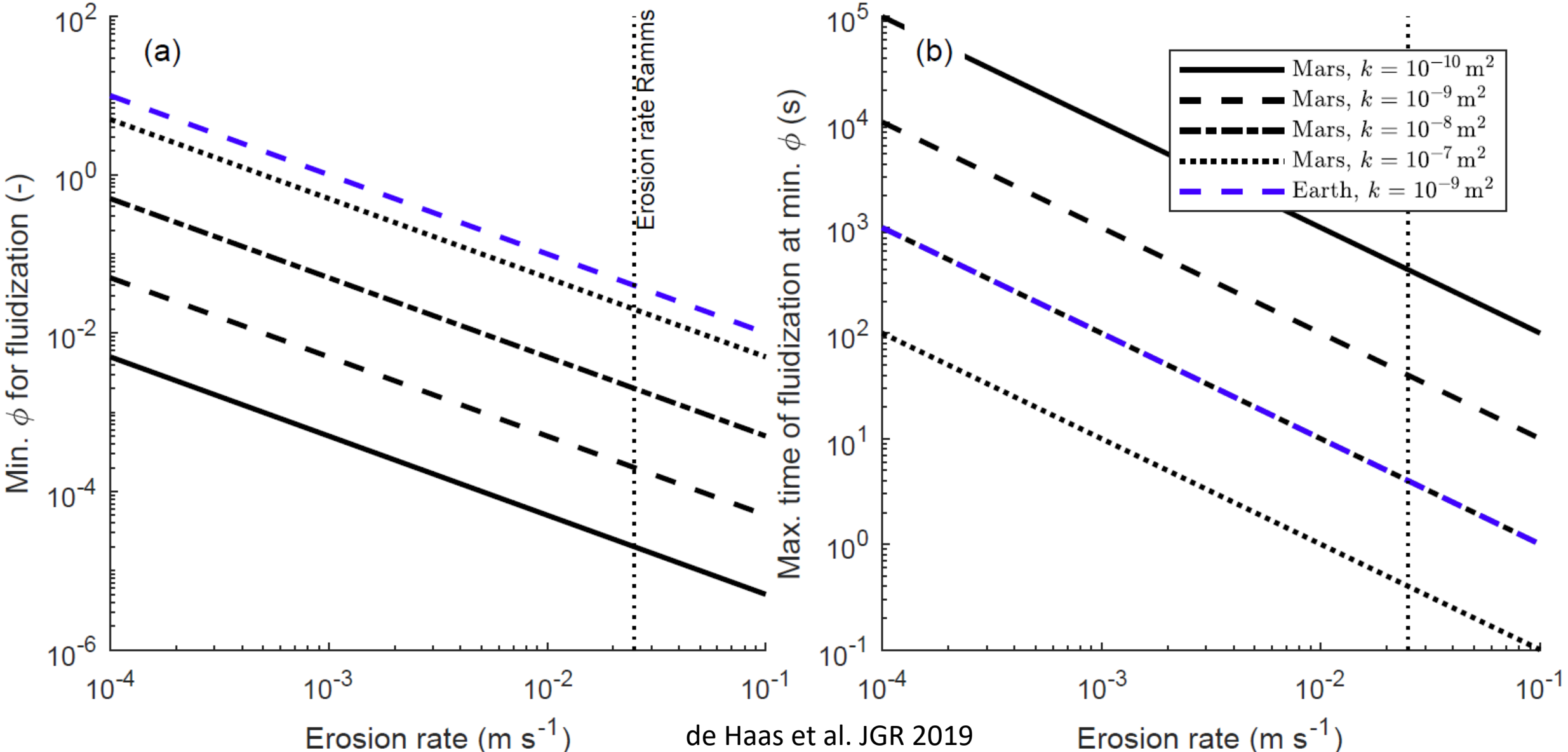
- **Liquid water** has flown on **Mars** in the past

- Currently no liquid water
- **Sublimating CO_2** ice can **mobilize** and **transport** sediment under **Martian atmosphere**

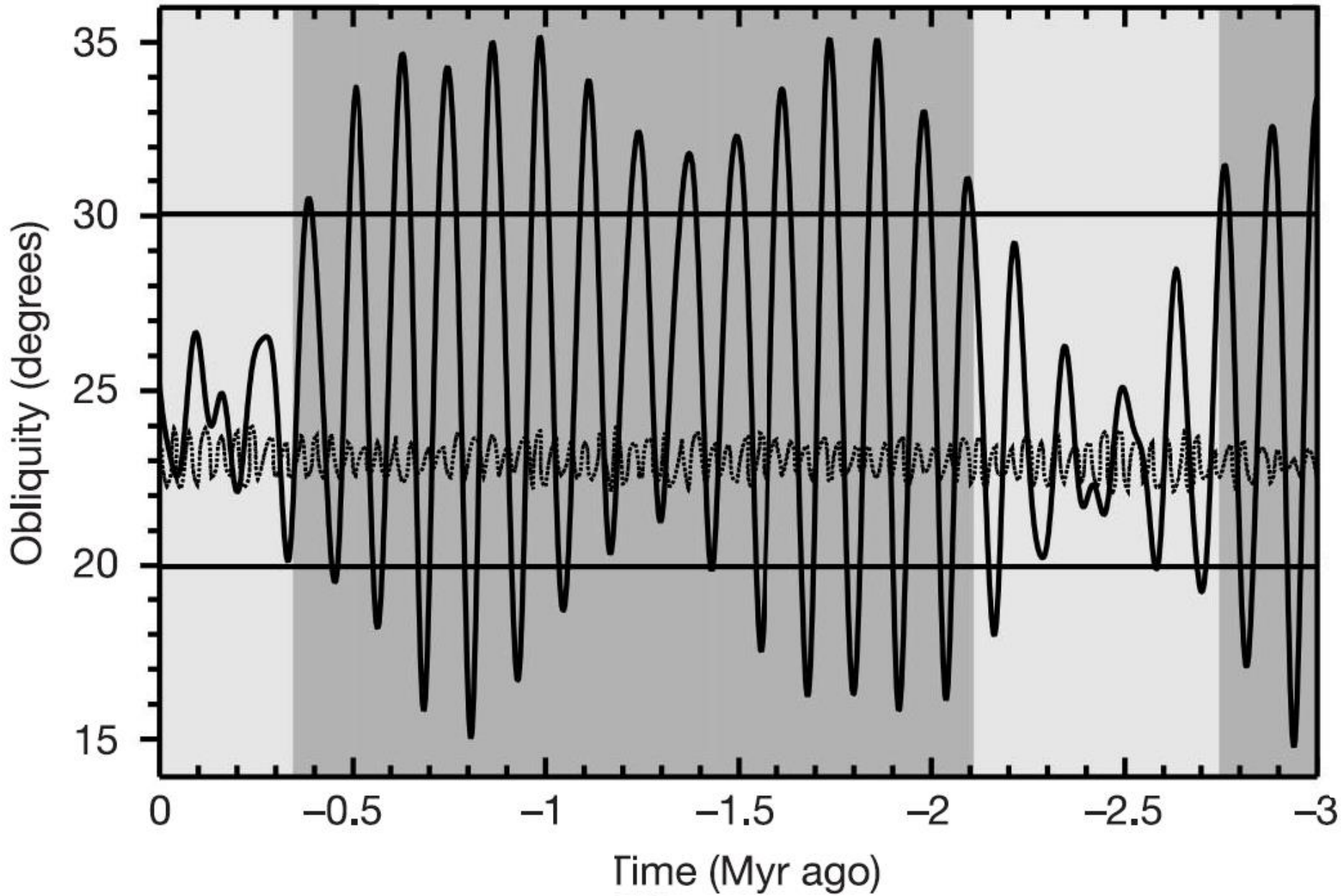
- The **low Martian pressure** is key → large gas fluxes during sublimation

- Applying earth scientific knowledge to understand planets is great fun!
  But beware of equifinality…

Extremely small amounts of CO_2 required



de Haas et al. JGR 2019


35
30
25
20
15
Obliquity (degrees)
0
–0.5
–1
–1.5
–2
–2.5
–3
Time (Myr ago)